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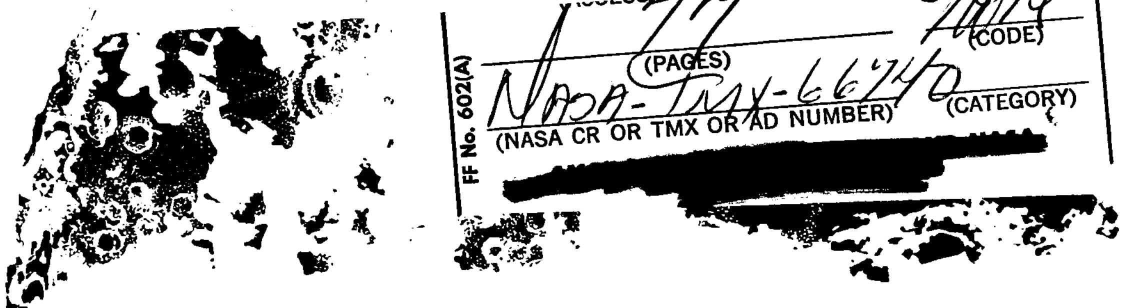

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT APOLLO [U]

QUARTERLY STATUS REPORT

NO. 4

FOR PERIOD ENDING

JUNE 30, 1963

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO SPACECRAFT PROJECT

QUARTERLY STATUS REPORT NO. 4

FOR

PERIOD ENDING JUNE 30, 1963

by Manned Spacecraft Center

FOREWORD

This report is the fourth in a series of reports on the status of the Apollo Spacecraft Project for the manned lunar landing program. The third status report described the development of spacecraft modules and systems through March 31, 1963. This report reflects activities and changes in status during the second quarter of 1963.

SUMMARY

The spacecraft and launch vehicle, being developed by the Manned Spacecraft Center (MSC) and the George C. Marshall Space Flight Center (MSFC), respectively, comprise the Apollo space vehicle (figure 1). The Apollo spacecraft configuration is shown in figure 2.

The spacecraft is composed of separable modules, including a Command Module (C/M) which houses the crew from the earth to the vicinity of the moon and return to the earth, a Service Module (S/M) which contains the propulsion system as well as other systems, and a Lunar Excursion Module (LEM) which separates from the Command and Service Modules when in lunar orbit and descends to the lunar surface for manned exploration.

The Saturn V will be the basic launch vehicle for lunar missions. The Saturn V consists of three stages: the S-IC, S-II and S-IVB. The S-IC uses LOX-RP-1 propellants for five F-1 engines. The S-II stage uses LOX-LH_2 propellants for five J-2 engines. The S-IVB stage uses LOX-LH_2 propellants for one J-2 engine.

Major accomplishments of the Apollo Spacecraft Project during this reporting period were:

a. Contract negotiations with all major contract elements for the Apollo spacecraft have been completed.

b. The wind tunnel program on the Command and Service Modules is 90 percent complete.

c. The first flight test articles (Boilerplate No. 6 and Qualification Test Unit No. 1) for pad abort and Little Joe II tests have been completed and are ready for testing at White Sands Missile Range, N. M.

d. The majority of the LEM subsystems contractors have been selected, and work is underway.

e. The guidance computer for the Command Module Guidance and Navigation System has been redesigned to increase the capacity of the fixed memory from 12,000 words to 24,000 words.

MISSION PLAN

The objective of the Project Apollo lunar landing mission is for manned expeditions to carry out limited scientific observations on the lunar surface followed by the safe return of the crew to earth.

A revised version of the Apollo Lunar Landing Mission Design Plan document was distributed in April 1963 to the various spacecraft contractors and to the NASA centers. This revised version contained more detail than the previous edition, particularly in the trajectory analysis and contingency operations sections. Although the emphasis in the mission profile was on designing for maximum flexibility rather than for a specific mission, a single reference trajectory for a typical mission was included in order to better orient the reader.

Major developments during this quarter in the mission planning area included the following:

a. Definition was made of the minimum and maximum duration of each phase of the Apollo lunar landing mission to which the spacecraft must be designed.

b. The impulse requirements of the LEM were studied in detail by MSC and Grumman Aircraft Engineering Corporation, and a LEM Delta V budget was subsequently specified to Grumman Aircraft Engineering Corporation.

c. Mission profiles were specified to North American Aviation, Inc. on which will be based the reliability analyses for determining the probability of mission success and crew safety. North American Aviation, Inc. will also analyze additional missions supplied them to determine their impact on systems design. The results of these studies will be available during the next quarter.

A similar exercise is proceeding with Grumman Aircraft Engineering Corporation to specify the mission models to be used for calculating crew safety and mission success. This will be completed in the next quarter.

d. A six-month study of contingency analysis during lunar operations was completed by the General Electric Company Apollo support group.

e. Grumman Aircraft Engineering Corporation effort is continuing satisfactorily on their first mission analysis report which is due early in the next quarter. Efforts are beginning at Grumman Aircraft

Engineering Corporation and are being coordinated with current studies at North American Aviation, Inc. on a detailed abort logic program which will ultimately be used to determine the best course of action and required procedures in the event of a contingency during the Apollo mission.

f. North American Aviation, Inc. is updating their lunar landing mission operations analysis report. The revised version, due next quarter, will include contingency operations and crew activities. A preliminary version of a similar analysis for a typical earth orbital mission has been completed.

g. Mission planning for the unmanned orbital Boilerplate No. 18 mission, the unmanned suborbital Airframe 009 mission, and the manned orbital Airframe 011 mission is proceeding to establish the spacecraft configurations and the preliminary mission plans. This will be completed early in the next quarter.

SPACECRAFT AND ADAPTER DESIGN AND DEVELOPMENT

The Apollo Command Module, Service Module, and Lunar Excursion Module are shown in figure 3. An adapter provides the attachment between the launch vehicle and the spacecraft. The Lunar Excursion Module is housed within this adapter during launch.

North American Aviation, Inc., Space and Information Systems Division, is the prime contractor for development of the Command and Service Modules, adapter, associated ground support equipment (GSE), and spacecraft integration. The two major associate contractors are Massachusetts Institute of Technology (MIT) Instrumentation Laboratory, responsible for development of the guidance and navigation system, and Grumman Aircraft Engineering Corporation, responsible for development of the Lunar Excursion Module.

COMMAND AND SERVICE MODULES

The Command Module, shown in figure 4, is the space vehicle command center from which all crew-initiated control functions are performed during the launch, translunar, transearth, earth reentry, and landing phases of the mission.

The Service Module, shown in figure 5, is unmanned and contains the propulsion system for midcourse correction, entry into lunar orbit, exit from lunar orbit, and for lunar-orbit rendezvous as a backup to the Lunar Excursion Module propulsion. The Service Module is non-recoverable and will be jettisoned prior to earth reentry.

Launch Escape System

A total of eleven successful firings have been conducted with the launch escape motor. Two igniter firings with hotwire cartridges showed no change in output characteristics over the exploding bridge wire version. Development testing is scheduled to be completed by July 8, 1963.

Eleven pitch control motors were fired during this period. During lateral acceleration testing in which a motor was fired under g loading, the aft closure bolts failed due to over-pressurization of the motor. It was found that a nozzle sized for a 1,700-lb-sec impulse motor had been installed on a 3,000-lb-sec impulse motor. This test will be repeated. Development testing is scheduled for completion by July 15, 1963.

Five tower jettison motors with modified nozzles were fired during this period. One of these motors utilized hotwire cartridges. The development program is to be completed by July 16, 1963.

The launch escape system configuration is shown in figure 6.

Command Module Structural System

Thermal expansion between the forward heat shield and the crew compartment heat shield is expected to cause excessive gap widths between the two shields. Designs to eliminate the gap are being studied.

The explosive bolt between the launch escape system tower and the Command Module has been redesigned to incorporate a linear-shaped charge separation mode in addition to the explosive separation. Two sources for the bolt are being selected for parallel programs. The bolt is scheduled for first flight usage on Boilerplate No. 12.

Service Module Structural System

All structural design drawings for the Servide Module were released during May 1963, as scheduled.

Venting requirements for the Service Module and adapter have been coordinated with MSFC for launch vehicles SA-6 through SA-111. The venting scheme as recommended was accepted by the MSC-MSFC Mechanical Integration Panel on May 8, 1963.

Tests of two major Service Module components have been completed. In the radial beam test (ATR 301-5), completed May 3, 1963, the beam sustained all imposed loading conditions. The aft bulkhead test specimen (ATR 301-3) failed at 125 percent of the limit load for the first stage and boost condition. Local crushing of the honeycomb core under the fuel tank support skirt caused a bond delamination of the bulkhead facing sheets and honeycomb core. The aft bulkhead will be redesigned as follows:

a. The density of the honeycomb core under the tank support skirt will be increased to eliminate the local crushing.

b. The joint between the aft bulkhead and radial beams will be slightly modified to obtain better load distribution.

Crew Equipment

The crew couch is being redesigned in accordance with the following:

a. One-position couch (that is, no translation along the Z-axis)

b. Fixed back angle of 2 degrees (measured from a plane normal to the spacecraft X-axis)

c. Special provisions for utilizing rendezvous windows

d. Provisions for folding legs to provide additional stroke on earth impact

e. Relocation of main panel to provide more effective reach and vision.

An analysis of the MSC-sponsored human impact test programs has resulted in changes to the nominal or normal mission impact tolerance limits. The limits now being used for the Apollo Earth Landing System design are shown in table I.

TABLE I.- EARTH LANDING SYSTEM DESIGN LIMITS

	NOMINAL		EMERGENCY	
	Peak g	Onset g/sec	Peak g	Onset g/sec
Forward (eyeballs in)	20	10,000	40	10,000
Backward (eyeballs out)	20	10,000	40	10,000
Lateral (eyeballs side-ward)	15	1,000	20	1,500
Headward (eyeballs down)	15	500	20	500
Tailward (eyeballs up)	15	500	15	5,000

MSC is continuing the test programs, with special emphasis on combinations of the directions listed in table I.

MSC and North American Aviation, Inc. have completed a comprehensive review of the initial phase of the Apollo centrifuge program. The schedule is realistic for a starting date in the third quarter of 1963. Consideration is being given to delaying the program six to eight weeks in order to permit completion of an MSC physiological program on the centrifuge. North American Aviation, Inc. is investigating the effect of such a delay on their overall system requirements.

North American Aviation, Inc. has redesigned the main control panel to be compatible with the new couch design; the design change has slightly altered the angle of the panel and has lowered the top of the panel toward the blunt end of the spacecraft. The new panel will have more total area than previously; it will present to the crew less height but slightly more width. Layouts of the panel were completed during June 1963 and are now under review by the MSC.

The rotational hand controller will be similar in appearance and pilot operation to the Gemini controller; mechanization of the controller will differ from the Gemini system in order to meet Apollo requirements.

The window covers have been deleted. A heat resistant recessed window design has been adopted; the new design will provide external visibility during launch and make Command Module heat protection less dependent on the operation of mechanical devices.

MSC and North American Aviation, Inc. are currently examining operational approaches and earth vs. spacecraft sensor trade-offs in order to define the spacecraft radiation instrumentation system.

Environmental Control System (ECS)

A separate tank to contain freon for boost cooling was added. The capacity of the potable water tank was reduced from 64 pounds to 36 pounds. The net effect of these and other minor changes is a reduction in weight and an increase in the reliability of the water management system.

The earth orbit capability of the ECS is at least ten days for a worst-case radiator orientation. This capability is extended to a full 14 days with radiator orientation.

The requirement for provisioning the ECS water tanks with post-landing water has been deleted. Spigots to provide access to water remaining in the tanks after landing will still be provided. Eighteen pounds of postlanding survival water is furnished in the survival kit.

The addition of a surge tank to the oxygen supply system to maintain cabin pressure above 3.5 psia for a short period of time during severe cabin leakage has enabled deletion of the 7,500-psia GOX entry supply assembly. The 14-in. inside diameter surge tank containing approximately 4.5 pounds of GOX at 900 psia will be the primary entry oxygen supply source. A redundant entry oxygen supply source is a portable life support system connected to the ECS.

North American Aviation, Inc. received the first shipment of coldplates manufactured by Atomics International. Testing of the coldplates will begin on July 1, 1963. North American Aviation, Inc. will manufacture airframe coldplates in-house.

AiResearch is conducting extensive water boiler tests. Results indicate that back-pressure control will be required to exercise satisfactory transient control. Freeze resistance of the present glycol evaporator configuration has been deemed satisfactory.

General Technology Corporation has been chosen to furnish the vacuum chamber and pumping system which will be used in the ECS breadboard tests. Progress on the basic facility has been satisfactory. Unmanned tests are scheduled to begin in October 1963, and manned tests will begin in January 1964.

North American Aviation, Inc. will procure a NASA-developed CO_2 sensor for use in the Command Module. NASA will completely qualify this unit, and North American Aviation, Inc. will buy it on a part number basis.

North American Aviation, Inc. negotiations with AiResearch have proceeded satisfactorily throughout this quarter. North American Aviation, Inc. has published the formal ECS procurement specification, and negotiations should be concluded early in the next quarter.

Guidance and Navigation System

The Raytheon Corporation selected the Fairchild Company to supply the first production quantity of TO-47 micrologic units for the Apollo guidance computer and related GSE. In accordance with the schedule recovery plan, all Apollo guidance computer Class B drawings were released.

The Guidance and Navigation System GSE schedule requirements are being met by AC Spark Plug, Raytheor Corporation, and Killsman Instrument Corporation.

Three pulse integrating pendulum accelerometers were delivered to MIT by the Sperry Gyroscope Company, bringing the total to twelve.

A total of ten inertial reference integrating gyros have been delivered to MIT by AC Spark Plug.

The AC Spark Plug, Raytheon Corporation, and Kollsman Instrument Corporation Statement of Work amendments for field support and associated spares were prepared. The general requirements were negotiated with the participating contractors, and a cost proposal for this effort is presently undergoing analysis. The negotiation for this effort will begin in late July.

The MIT studies have shown that the method of translunar injection requires 400 words of computer storage, and the midcourse guidance method requires 500 words of computer storage. The original estimate for translunar injection and lunar orbit de-boost was a maximum of 1000 words, but this requirement is now accurately estimated at only 400 words.

The AC Spark Plug contract was reviewed and approved by NASA Headquarters with certain clarification comments. Since AC Spark Plug had already signed this contract, these comments are being reviewed with AC Spark Plug.

Stabilization and Control System

The Stabilization and Control System design was frozen on June 21, 1963 subject to formal change control subsequent to this date. The circuit development for the attitude gyro accelerometer package logic was completed. The functional breadboard of the ΔV display was completed, and all compatability problems were resolved. The manual control design specification revision was completed. The drawings were released for the bench maintenance equipment functional Model A.

Satisfactory progress is being made in all design and development areas, and approximately 85 percent of the Stabilization and Control System is in breadboard test.

Astronauts evaluated the two hand controller revisions at Minneapolis-Honeywell Regulator Company and recommended that the rotational controller be a "stand-up" type stick with the pitch and yaw axes pivot points mechanized through the palm of the hand and the roll axis pivot mechanized through either the center of the hand or at the base of the hand below the pitch-yaw pivots.

Layout of the rate gyro package electronics has been completed, and the detailing of parts has started. Detail drawings for the rate gyro package and for the attitude gyro accelerometer package main casting have been completed and released to the vendor. The attitude gyro accelerometer package test set design is 50 percent complete. Manual controls test set drawings were released, and fabrication is 60 percent complete. North American Aviation, Inc. has directed Minneapolis-honeywell Regulator Company to procure interface connectors directly from the vendor, Hughes Aircraft Company.

The prototype Stabilization and Control System/Service Propulsion System gimbal actuator was received by North American Aviation, Inc. from Aerojet General Corporation, and preliminary low frequency tests on the engine inertia simulator verified the actuation response characteristics.

A total of twelve interface coordination documents between North American Aviation, Inc. and Massachusetts Institute of Technology on the Guidance and Navigation/Stabilization and Control System interface have been signed off.

Reaction Control System

Five experimental Command Module engines with an expansion ratio of 10:1 have been fired in the pulse width versus char depth test series. All engines completed the required burning time with no significant degradation in performance. Overall performance was better than theoretically predicted for this configuration.

Four additional engines with an expansion ratio of 10:1 have been tested to the Apollo mission duty cycles at altitude conditions.

Modified inner ablative, combustion-zone inner liners were tested in three of these engines to reduce material "spalling" which had previously occurred. Significant improvement was obtained with the modified liners, one of which will be incorporated in the prototype design release.

The completion of phase I and II jet plume tests concluded the Service Module Reaction Control System plume visualization and impingement test series. Results have been in agreement with the theoretical predictions, and no further tests are contemplated.

Two pre-prototype Command Module engines with 40:1 expansion ratios have been fired with varying pulse widths of from 10 to 50 milliseconds. Firings were primarily intended to check out impulse bit-measuring capabilities of the facilities. It was indicated that some modifications may be necessary to insure reliable data.

Service Module Propulsion System

During this reporting period, the first simulated engine was delivered to North American Aviation, Inc. and installed on the F-3 Test Fixture. Preliminary cold flow tests were started but were suspended for a short interval to allow installation of a new propellant line configuration. This new configuration is a result of lowering the engine approximately 10 inches. Preliminary test data from the heat exchanger test fixture at North American Aviation, Inc./Downey indicated that low pressure heat exchangers are the proper configuration for the Service Propulsion System. These tests were run with battleship heat exchangers manufactured in-house by North American Aviation, Inc., and the test results are very encouraging.

The manufacture of Test Fixtures F-1 and F-2 proceeded on schedule. These fixtures will be installed at Sacramento, California, and White Sands Missile Range, respectively, during the next quarter.

During this period, subvendors began work on many of the major components of the Service Propulsion System.

Allison Division of General Motors Corporation, the propellant tank manufacturer, built and tested a model propellant tank. A Minuteman tank was fabricated to Apollo specifications to prove the technique of fusion welding titanium with local inert gas shielding instead of an inert gas chamber. The tank sustained 1,500 normal pressure cycles without failure and was then purposely overpressurized until failure occurred at the predicted burst pressure.

Acceptance testing of the first full scale Arnold Engineering and Development Center (AEDC) engine was completed at the Aerojet facility in Sacramento, California, and the engine was shipped to AEDC on May 22, 1963. Problems encountered by AEDC test personnel during the preparation of their test facilities delayed completion of the engine installation until June 21, 1963. Hot firing tests continued to be delayed by the difficulty of lowering the cell pressure to the level required for operating the 60:1 area ratio nozzle.

During fabrication of the columbium-titanium nozzle extension, cracking in the heat-affected zone was detected. Tests were conducted on welded samples to determine corrective action, and improved techniques are now being used in the fabrication process. The first columbium-titanium nozzle was coated with a nickel-aluminum-silicon composition applied by the Advanced Materials and Processes Co., Los Altos, California. This nozzle was shipped to AEDC for use on the first test engine.

A conservative nozzle extension design was initiated to insure that Phase I testing at AEDC would not be delayed because of development problems with the columbium-titanium nozzle. The backup design employed an all-titanium nozzle skirt strengthened radially and longitudinally with Haynes alloy 25 stiffeners riveted to the titanium. Attachment of the nozzle skirt to the ablative chamber was accomplished with a flared sheet-metal flange at an area ratio of 12:1.

Injector development efforts were concentrated on the unbaffled quadlet and doublet patterns. A combustion efficiency (C*) of 98 percent was demonstrated with each pattern, but initial tests with ablative chambers resulted in excessive ablation and slight streaking. Modifications were made on each pattern, and improvements in thrust chamber compatibility were obtained. Start transients were improved by balancing the propellant distribution in the injector headers through the installation of flow deflectors in the headers at the outlets of the thrust chamber valve.

Thrust chamber valve tests have shown both stable-start and steady-state transients. Simulated malfunction tests made by actuating only one bank of the valve indicated only a small degradation in thrust.

Two non-firing (simulated) engines were delivered to North American Aviation, Inc. for use as cold flow and fit check fixtures. Delivery dates were April 8, 1963 and June 8, 1963.

Communication System

All communications subsystems have been functionally breadboarded, and all parts for engineering models ("E" Models) have been ordered.

A two-point, in-flight calibration system has been included within the pulse code modulation equipment.

The requirement for a loud speaker in the command module has been deleted.

The up-data implementation plan and preliminary specification which were prepared by North American Aviation, Inc. have been reviewed by the Manned Spacecraft Center.

MSC has decided to use a PAM/FM/FM telemetry system for accommodating flight qualification telemetry requirements on Airframes 009 to 011.

Action has been initiated to provide an electrostatically-focused klystron made by Litton Industries, Inc. as a backup to the traveling-wave tube made by Hughes Aircraft Corporation.

The HF transceiver carrier frequency has been changed from the 15 mc region to 10.006 mc to improve RF propagation and to reduce equipment complexity.

Collins Radio Company has received contractual authorization from North American Aviation, Inc. to delete pulse mode operation and to proceed on the design of a 3-watt cw VHF recovery beacon.

North American Aviation, Inc. has awarded the directable high-gain S-band antenna contract to Avien, Inc.

Operational Instrumentation System

Inflight calibration at the transducer level has been deleted.

North American Aviation, Inc. has received and evaluated responses to the pressure, temperature, and accelerometer specifications.

The synchronization pulse output from the guidance computer to the central timing equipment has been changed from a 512-kc to a 1024-kc rate.

North American Aviation, Inc. has been directed to modify the data storage equipment to provide for a 3.75 ips record speed and a 120 ips fast dump speed. The 14 ips mode will be maintained. A parallel effort will be initiated to allow present "E" Model development to continue on schedule. The change will be reflected in the first development unit or "D" Model.

North American Aviation, Inc. has completed specifications on the proton-directional and solar RF alert subsystems of the Radiation Instrumentation System.

The signal conditioner installation design has been changed to allow ease of maintenance. This has resulted in a weight increase of approximately three pounds due to additional heat sink requirements encountered.

The following contracts have been awarded:

a. United Electrodynamics, Inc. - signal conditioner amplifier modules.

b. Vector Manufacturing Company - signal conditioner ac/dc converter modules

c. Epsco, Inc. - signal conditioner attenuator modules.

Electrical Power System

A Westinghouse Electric Corporation inverter breadboard has been delivered to North American Aviation, Inc. Performance of the inverter breadboard shows warm-up time, frequency modulation, amplitude modulation, and harmonic distortion to be within specification limits.

The Boilerplate No. 6 sequencer has been modified to provide a second arming relay and a GSE hardline monitoring capability. The Boilerplate No. 12 sequencer has been redesigned for hot-wire initiators and for the provision of separate logic and pyrotechnic busses.

An engineering model of the International Telephone and Telegraph Corporation battery charger has passed electromagnetic interference tests.

Entry and post-landing battery drawings for fabrication and assembly of batteries have been released. Development testing has begun at Eagle Pitcher Company on a 20-cell prototype entry battery. Battery weight is now 22 pounds.

Table II shows fuel cell test hours which had been accumulated as of June 12, 1963.

TABLE II.- FUEL CELL TEST DATA

	Total Times Tested	Load Time, hr	Longest Single Test of Load, hr
Single cell	38,144	13,683	605
Six-cell stack	4,364	2,453	438
Thirty-one cell stack	1,951	596	178
Independent module	1,510	570	192

The sequencer design as it is now proposed is as follows:

a. The automatic functions of the sequencer are:

(1) The programing of the Launch Escape System rocket motors and structure release mechanisms upon receipt of an abort signal

(2) The control of the parachutes of the Earth Landing System for either a normal landing or in conjunction with an abort.

b. Manual functions include the jettisoning of the Launch Escape System tower and the release of the main parachutes after earth contact.

c. The circuitry used to control the pyrotechnic devices will contain the following features:

(1) Redundant systems with no interconnections

(2) Separate pyrotechnic and logic busses

(3) Separate pyro batteries with no electrical load other than the electro-explosive devices

(4) Provisions for monitoring the position of all firing switches prior to arming

(5) Solid-state timers connected to preclude a premature signal

d. Spacecraft sequencers will employ solid-state devices for all timing and switching functions and motorswitches for the firing of electro-explosive devices. Prototype sequencers used on the early boilerplate tests have some non-solid components and relays.

Earth Landing System

A total of sixteen parachute tests were conducted at El Centro, California, during this reporting period. Two successful drogue parachute tests and a three-cluster parachute Parachute Test Vehicle test with the ring-sail effective reduced porosity in the crown (PDS 1543) were performed. Two modified ring-sail configurations were tested. There were four single-parachute tests and one two-parachute cluster test with the half-ring said/half-solid (PDS 2072) configuration. One half-ring sail/half-ring slot (PDS 2071) two-parachute cluster test was also conducted. Both ring-sail modifications resulted in severe cluster aerodynamic interference with attendant high loads which caused failure.

There were four Pioneer Parachute Company solid triconical parachute tests. The two-parachute cluster test resulted in aerodynamic interference similar to that observed on the ring-sail cluster tests. Resulting high loads caused one canopy to fail.

Three successful Earth Landing System tests were conducted with Boilerplate No. 2 in support of Boilerplate No. 5 PA-1. The Earth Landing System configuration is shown in figure 7.

Boilerplate No. 19 was shipped to El Centro for testing, and it is now being modified to the Boilerplate No. 3 configuration.

The suspension angle of the Command Module has been changed from 5° to 30°. Tests are continuing with Boilerplate Nos. 1 and 2 suspended at this angle. A total of 20 impact tests were conducted during this reporting period.

Heat Shield

A study of alternate heat shield materials by North American Aviation, Inc. was concluded on June 10, 1963. The low-temperature performance of the T-500 material made by Emerson Electric Manufacturing Company and the 325 material made by Dow Corning Corporation limit the potential application on Apollo; therefore, North American Aviation, Inc. has discontinued work on the alternate heat shield.

Adapter

The preliminary size of the adapter for the Saturn C-5 and S-IB is 350 inches in length. The LEM will be supported in the adapter from a fixed structure on the landing gear. Information showing that the overall length of the Saturn V spacecraft adapter had been increased from 318 to 350 inches was officially transmitted to MSFC on June 3, 1963.

LUNAR EXCURSION MODULE

The Lunar Excursion Module serves as a shuttle vehicle for transferring two of the three crew members and their payload from the Command Module in lunar orbit to the lunar surface and then returning them to the Command Module. Included in this operation are the functions of separation from the Command Module, lunar descent, lunar landing, ascent, and rendezvous and docking with the Command Module.

Following contract award in January 1963, Grumman Aircraft Engineering Corporation undertook a study program with the following priority items to receive emphasis during the first four months: cabin size, distribution of equipment and consumables, fire-in-the-hole, visibility, ingress-egress, docking requirements, tankage sizing, thrust-vector control, and target weights.

The study has been completed, and figure 9 illustrates the resulting LEM configuration.

Salient features of the configuration are discussed in subsequent sections.

LEM Structure

The LEM structure has reached the point at which certain design features of the configuration are considered to be firm. The ascent stage has a horizontally-mounted cylindrical cabin with a smaller diameter equipment compartment immediately aft of the upper docking tunnel. The forward cabin face has not been configured, but its design will be determined by visibility requirements and the docking system. The ascent stage propellant tanks are vertically stacked on the Y-axis, outboard of the cabin.

The LEM descent stage structure consists of two pairs of crossed vertical beams in the shape of a cruciform. The oxidizer tanks are located on the Z-axis and the fuel tanks are on the Y-axis. This shape accomodates the four-leg deployable gear.

A study of LEM visibility requirements has begun at Grumman Aircraft Engineering Corporation and MSC. The study goal is to define crew visibility requirements for landing, take-off, rendezvous, and docking in order to configure the cabin transparency sizes and locations.

Grumman Aircraft Engineering Corporation has been directed to study the effects of supporting LEM in the adapter by a fixed portion of the landing gear. Implications on structural load paths, dynamics, weight, and adapter separation will be investigated.

LEM Landing Gear

It is anticipated that the landing gear radius and folded envelope will be selected in July 1963. The gear will have four legs and will be deployable.

A 1/6-scale landing gear model has been completed. Preliminary drop tests have been made to verify the computer stability program. Correlation has been good. The model is currently being updated to the latest weight, center of gravity, and moment of inertia characteristics.

An interpretation of the lunar surface given in the Statement of Work, for use in landing gear design and stability analysis, has been furnished to Grumman Aircraft Engineering Corporation. This gives an effective slope of approximately 11° for the size landing gear presently under consideration and a total protuberance-to-depression height of approximately 24 inches.

Crew Equipment

Regarding crew equipment, Grumman Aircraft Engineering Corporation and the MSC have resolved the following:

a. Suit evaluation is expected to include a vehicle mockup installation in an aircraft flying zero and 1/6g trajectories.

b. The suit assembly emergency oxygen supply will be employed as the backup pressurization-and-oxygen supply during crew transfer from the Command Module to the Lunar Excursion Module. This does not relieve the requirement for being able to effect crew transfer, employing the Portable Life Support System, in the event the LEM cannot be pressurized normally.

c. The four-hour operating cycle (Design Requirement) for the Portable Life Support System should not be considered for normal operation. The defined use cycle is three hours, with a one-hour contingency.

d. Pending final definition of a waste management scheme, Grumman Aircraft Engineering Corporation will retain provisions for spacecraft stowage of human wastes.

e. The thermal garment will not normally be worn while inside the LEM because of its affect on mobility. It will be donned only during preparation for egress or during prolonged cabin decompression. The MSC is studying the Command Module requirements for the garment during an unpressurized earth return. If no requirement exists, the thermal garments will be stowed in the LEM.

f. The Portable Life Support System battery will be charged before earth launch. Oxygen and water cannot be charged before launch because of the cabin temperature variations during translunar flight. Tentatively, the water will be recharged directly from the drinking tube.

The Massachusetts Institute of Technology has proposed the replacement of the scanning telescope within the guidance and navigation system with a fixed-base telescope. Grumman Aircraft Engineering Corporation was informed of this new approach and was requested to determine the net effect of the proposed change. Early indications are that extra uses for the scanning telescope can be alternately accomplished, and the significant weight savings for the MIT-proposed change can be realized. Conclusive evaluation, however, is not yet complete.

MSC is conducting a preliminary assessment of Lunar Excursion Module crew visibility requirements. In order to insure maximum validity and utilization of results, the effort is being planned (objectives, procedures, phasing, configuration, et cetera) with Grumman Aircraft Engineering Corporation inputs. A facet of the study is to include a series of helicopter flights in which earthshine lighting conditions and LEM window configurations will be simulated and both related to helicopter landing techniques along representative LEM trajectories. Preliminary results are expected by mid-August 1963.

Requirements for LEM controls and displays have been preliminarily defined as a result of a subsystem-by-subsystem functional analysis. Subsystem parameters which require display or control are currently included. The subsystem panels have not been finally integrated into a total panel, but alternate arrangements are being devised.

LEM Environmental Control System

Grumman Aircraft Engineering Corporation has issued the preliminary design control specification and vendor requirements document for that portion of the Environmental Control System (ECS) which is to be subcontracted to Hamilton Standard Division of United Aircraft Corporation. Both documents are now being revised to reflect changes resulting from negotiations with Hamilton Standard and recommendations by the MSC. The major effects of these changes are increased weight and power requirements and a delay in the receipt of prototype models at Grumman Aircraft Engineering Corporation.

Grumman Aircraft Engineering Corporation is studying the possibilities of designing the LEM suit circuit fan to be physically interchangeable with the Command Module fan. This study was initiated in an effort to increase Command Module ECS reliability by providing an additional backup fan.

It has been determined that it is both feasible and desirable to design the LEM ECS to utilize Portable Life Support System lithium hydroxide cartridges for carbon dioxide control. Further study of this concept will be conducted by Hamilton Standard since all work to date has been purely analytical and must be verified by test.

Grumman Aircraft Engineering Corporation and the MSC have agreed on an ECS common usage list of eleven items which will be incorporated into the vendor requirements document. Five of the items interface with the space suit or Portable Life Support System. The remaining items are:

a. Compressor check valve.

b. Coolant pump.

c. Coolant accumulator.

d. Water check valve.

e. Water shut-off valve.

f. Ground support equipment coolant disconnect.

LEM Guidance and Navigation System

The Statement of Work describing the three participating contractors' effort in supporting the LEM guidance and navigation conceptual design was prepared. The contractors are Kollsman Instrument Corporation, A.C. Spark Plug Division of General Motors Corporation, and Raytheon Company.

The procurement plan covering the LEM guidance and navigation development, fabrication, test and field support is being prepared, and is expected to be forwarded to NASA Headquarters by late July 1963.

LEM Stabilization and Control System

The Grumman Aircraft Engineering Corporation report on common usage was completed, and joint agreement with MSC was reached on recommended common usage items.

The LEM Stabilization and Control System preliminary development plan was completed.

LEM Reaction Control System

The Reaction Control System (RCS) design and installation lay-out has been defined by the contractor with MSC concurrence. The design incorporates dual-interconnected units with provisions for emergency supply of propellants from the main ascent propulsion tanks. The installation lay-out provides for modular packaging of tank and control components with minimum line disconnects and ready access from the exterior of the vehicle.

Common usage of RCS components between the LEM and the Service Module was analyzed in detail with the results that approximately 90 percent of the items were designated as "common usage," and they will be implemented according to the procedures agreed upon between MSC and Grumman Aircraft Engineering Corporation. These items will be reviewed as development progresses to assure the continued applicability to the LEM RCS requirements and design. Other reaction control systems were considered for potential common usage of their components; however, the Service Module RCS offered the most promise for direct application of designs and technology because of the basic similarities in design requirements.

Grumman Aircraft Engineering Corporation has completed the design of the RCS coldflow breadboard and has begun procurement action for off-the-shelf workhorse components. Initial testing of the helium pressurization system on the coldflow rig is expected to begin in August 1963.

Initial subcontract negotiations for the propellant system and thrust chambers were completed in April 1963. The revised procurement specification and vendor requirements were released in mid-May 1963, and final negotiations with the Marquardt Corporation are presently nearing completion. Development "go-ahead" for the propellant system is expected by late-July 1963. The thrust chamber assembly is a common usage item with the Service Module RCS; therefore, its development is not a part of the subcontract effort. The helium pressurization system is being developed "in-house" by Grumman Aircraft Engineering Corporation.

LEM Propulsion System

Ascent Propulsion.- Grumman Aircraft Engineering Corporation has been negotiating the ascent engine development program with Bell Aerosystems Company since the latter part of May 1963. Items yet to be resolved are engine weight, the thrust chamber development program, and the cost of special test equipment.

A parallel propellant feed system configuration has been selected for the ascent propulsion system because of the minimum center of gravity shift due to an off-design mixture ratio operation and because tank location is independent of the nominal engine mixture ratio.

Descent Propulsion.- Grumman Aircraft Engineering Corporation completed negotiations with Rocketdyne, and a tentative go-ahead was given to begin work on May 1, 1963. The first scheduled milestone was met when the Rocketdyne program plan was delivered to Grumman Aircraft Engineering Corporation on May 30, 1963.

Rocketdyne will retain the engine chamber pressure at 145 psia as originally proposed; however, Grumman Aircraft Engineering Corporation has relieved the 75-inch length constraint. Allowable engine length is now 87 inches.

Space Technology Laboratories, Inc. has been selected to develop the parallel descent engine. This engine will use a variable-area injector and cavitating venturis in the feed lines for throttling. Grumman Aircraft Engineering Corporation began negotiations for the development of this engine with Space Technology Laboratories, Inc. on June 6, 1963.

Grumman Aircraft Engineering Corporation studies have resulted in the selection of four cylindrical propellant tanks and a parallel propellant feed system for the descent stage.

LEM Communications System

Grumman Aircraft Engineering Corporation is preparing a communications subsystem specification for issuance to Radio Corporation of America who will, in turn, prepare separate hardware specifications for releasing to prospective vendors.

Grumman Aircraft Engineering Corporation will provide any VHF, C-band or command antennas required for the LEM during the LEM development program. The MSC will provide as government-furnished equipment any research and development instrumentation/communications system required during the development program.

As a result of a decision among NASA Headquarters, MSC, Jet Propulsion Laboratory, Marshall Space Flight Center, North American Aviation, Inc., and Grumman Aircraft Engineering Corporation, it was resolved that the Command and Service Modules and the Lunar Excursion Module would incorporate Deep Space Instrumentation Facility compatible, phase-coherent S-band transponders, each with its own allocated frequencies, as shown in table III.

The formal Apollo S-band frequency authorization requests have been completed and submitted to the MSC frequency manager for transmittal to NASA Headquarters.

TABLE III.- BEACON FREQUENCIES

	Command and Service Modules	Lunar Excursion Module
Transmit, mcps	2287.5	2282.5
Receive, mcps	2106.40625	2101.8

In order to increase the effective communication range between the LEM and the Command and Service Modules, and at the same time to minimize power consumption by utilizing all solid-state components, Grumman Aircraft Engineering Corporation has recommended the use of an "infinite clipping" modulation technique for the LEM. The MSC has tentatively approved this selection, pending hardware demonstrations by Radio Corporation of America.

Grumman Aircraft Engineering Corporation is currently conducting 1/10-scale antenna pattern studies. A 1/6-scale model is under construction.

LEM Operational Instrumentation

Grumman Aircraft Engineering Corporation's preparation of vendor requirements documents is proceeding as scheduled. The preliminary specifications for the pulse code modulation telemeter and the data storage equipment have been reviewed by the MSC. It is expected that the pulse code modulation vendor requirements document will be ready for release in late July, and the data storage equipment vendor requirements document will be ready in mid-August 1963. Both of these items are presently considered common usage equipment.

Due to the minimal LEM requirements placed on the scanning telescope, Grumman Aircraft Engineering Corporation is deleting it as a separate hardware item and incorporating the necessary timing capabilities into the pulse code modulation.

Common usage vendors are being selected to support the hardware programs of the LEM and the Command and Service Modules. The capabilities of several vendors are being studied, and final selections will be made after inspections of the vendors' plants by MSC personnel.

Grumman Aircraft Engineering Corporation has a contract with Francis Associates, Inc. to study the constraints and capabilities associated with the packaging of electronic equipment for the LEM.

The requirements for inflight crew check-out of the spacecraft are presently under study. Mechanization of the LEM inflight test system must await further definition of the spacecraft systems; however, test philosophy and mechanization trade-off studies are presently continuing.

LEM Electrical Power System

Grumman Aircraft Engineering Corporation presented the LEM electrical power load analysis which showed that at maximum vehicle weight, the total electrical energy required during the translunar phase would be 73.46 kw-hr with active subsystems and 57.94 kw-hr with passive subsystems. At the nominal vehicle weight, the total energy required is 57.6 kw-hr with active subsystems and 44 kw-hr with passive subsystems. In connection with the weight reduction program, Grumman Aircraft Engineering Corporation is present conducting an analysis of power requirements for each subsystem; after maximum control loads are established for each subsystem, target load levels will be set. Control load levels are to be used in the design of the Electrical Power System. Starting in September 1963, the electrical power load analysis is to be presented quarterly. The presentation will include total electrical energy requirements, average electrical power loads, and peak electrical power requirements.

Grumman Aircraft Engineering Corporation has released the vendor requirement documentation for the LEM auxiliary batteries. The documentation includes battery power requirements for normal, peaking, and survival loads. Information from battery suppliers is to be analyzed to determine the best auxiliary battery configuration for the LEM.

Grumman Aircraft Engineering Corporation has completed the first phase of a study of LEM interior lighting. Initial results of performance and brightness tests indicate that the most promising LEM interior lighting system would be electroluminescent panel lighting supplemented with 6-volt flood lighting. However, the lighting study will involve further considerations of reliability, weight, power conversion and control, heat dissipation, and other factors.

Initial steps toward procurement of the fuel cell power supply were completed during this reporting period. The fuel cell specification and the vendor requirements document were released for bid, and proposals were received from Allis Chalmers Manufacturing Company, General Electric Company and Pratt and Whitney Aircraft. The proposals were evaluated by both Grumman Aircraft Engineering Corporation and MSC, and Pratt and Whitney Aircraft was selected.

The Electrical Power System-ECS oxygen tank integration study is complete. The study indicated that the oxygen storage should be integrated in a single descent-stage tank and non-integrated in the ascent stage. The ascent-stage configuration consists of a supercritical oxygen storage vessel for the fuel cell and a gaseous accumulator for ECS requirements. The configuration of the feed system remains under study.

Similar studies related to the hydrogen tank configuration are also complete. The optimum configuration for hydrogen storage depends on, and will be established by, the fuel cell choice. Additional study of the tankage feed system is required.

LEM SPACE SUIT SYSTEM

The spacecraft is being designed for suits to be worn during earth launch and reentry, during certain critical mission phases in the Command Module, and at all times by the LEM crew.

Provisions are being made for storing two Portable Life Support Systems (PLSS) in the LEM and one in the Command Module. Two of the systems will be installed in the Command Module for missions conducted without a LEM.

Firm stowage locations for all space suits, Portable Life Support Systems, and supporting equipment have been determined; the only area remaining is the exact location of PLSS structural takeoffs for securing the PLSS to the spacecraft during high stress periods.

All Portable Life Support System charging provisions are well defined, and detailed design is proceeding. Recharging of oxygen, water, and lithium hydroxide can be done in a matter of minutes, but battery recharging takes considerably longer. The battery used in the Portable Life Support System has a "normal" charge time of six hours; the Command Module battery charger will complete the charging cycle in eight hours. The LEM charging system is under study; elements being considered are mission requirements, utility of partial charging, battery charger weight, and possible extra (replaceable) batteries.

Considerable effort has been spent to decrease suit shoulder width in order to meet limitations in couch and hatch width. As a result of recent shoulder design improvements, the suit manufacturer is confident that the maximum pressurized shoulder width will be 24.5 inches. This measurement will accommodate all of the astronauts - many of whom have shoulders which exceed 90th percentile dimensions.

The ventilation umbilicals will be separate round hoses with an inside diameter of 1.25 inch. Combined (two channel) hoses and hoses with an inside diameter of 1.0 inch were considered but were dropped because of high flow resistance. Although the round hoses will be "separate," they will be physically clipped together during flight.

LEM R AND D INSTRUMENTATION/COMMUNICATIONS SYSTEM

Government-furnished airborne equipment for Apollo Boilerplate Nos. 6, 12, 13 and 23 has been delivered to North American Aviation, Inc. and is in various stages of receipt, inspection, calibration, breadboard testing, installation,and spacecraft integrated tests.

Breadboard tests on government-furnished airborne equipment for Boilerplate No. 15 are in progress at MSC.

Tentative flight hardware lists and telemetry loading schedules have been prepared for Boilerplate Nos. 18 and 22, and release is pending North American Aviation, Inc. transmittal and MSC approval of recently revised measurement lists.

A requirement for cameras on Boilerplate Nos. 12 and 23 is being implemented, and cameras are expected to be shipped to North American Aviation, Inc. in the early part of July 1963.

A complement of R and D pressure transducers and accelerometers were furnished to General Dynamics/Convair for the Little Joe II qualification test vehicle.

LEM SCIENTIFIC INSTRUMENTATION

Two cubic feet of volume and eighty pounds have been allocated to lunar sample and data return. This weight figure includes the weight of the sample return containers. A study is underway to determine the envelope of the containers. The preferred configuration at present is 7.3 inches by 38 inches, which would make the sample return containers directly interchangeable with the Command and Service Modules' expendable carbon dioxide canisters. This would allow the maximum utilization of existing Command and Service Modules volume since the containers would be stowed in the Lunar Excursion Module until the return trip, at which time they would be transferred to the Command and Service Modules and into the then available area previously occupied by the carbon dioxide canisters.

Two five-cubic-foot areas in the Lunar Excursion Module landing stage have been allocated to the scientific payload. The present preferred configuration for electronic-type experiments is 8 inches by 8 inches by 8 inches and multiples thereof.

APOLLO SPACECRAFT WEIGHT

Table IV, on the next page, gives the status changes of the Apollo spacecraft weights, the control weights, and the design goal weights.

The major Command Module changes have been due to calculations of weight based on currently released structural drawings as well as revised weight estimates which are based upon current load information. As a result of these increases, a weight reduction program has been initiated by North American Aviation, Inc. in an effort to meet the Command Module design goal weights.

The major Service Module weight changes have been made due to the following reasons:

a. Increased component weight in the fuel cell hydrogen system

b. Increased weight of the oxygen tank support structure

c. Decreased weight of the basic structure determined by calculations instead of by estimates

d. Decreased weight of the Service Propulsion System propellant tank skirts because of a change from titanium to aluminum

TABLE IV.- APOLLO SPACECRAFT WEIGHT STATUS

Lunar Orbit Rendezvous Mission

	Control Weight, lb	Design Goal, lb	Current Weight, lb	Change From Last Report, lb	Remarks
A. Command Module (including crew)	9,500	8,500	9,170	+180	
B. Service Module	50,230	45,615	47,230	+280	ΔV margin = 10 percent
Inert (including residual propellants)	10,500	9,500	9,260	-160	$^{a}I_{sp}$ = 313.0 sec
Useable ^{b}SPS propellant (ΔV_2 = 4,801 fps)	12,200	10,980	11,460	+ 10	I_{sp} = 313.0 sec
Useable SPS propellant (ΔV_1 = 3,883 fps)	27,530	25,135	26,150	+430	
Total	50,230	45,615	47,230	+280	
C. Total Command Module and Service Module (Lines A + B)	59,730	54,115	56,400	+460	
D. Lunar Excursion Module (without crew)	26,370	24,500	25,400	+900	ΔV margin = 10 percent
Descent stage (ΔV = 7,827 fps)			17,370		I_{sp} = 305.0 sec
Ascent stage (ΔV = 7,079 fps)			8,030		I_{sp} = 303.0 sec
Total			25,400		
E. Adapter	3,400	3,000	3,110		
F. Effective Weight, Launch Escape System	500	500	500		
G. Total Spacecraft Injection Weight (Lines C + D + E + F)	90,000	82,115	85,410	+1,360	
Launch Escape System Weight	6,600	6,400	6,390	- 10	
Total Launch Weight	^{c}96,100	88,015	91,300		

$^{a}I_{sp}$ = Specific Impulse

^{b}SPS = Service Propulsion System

^{c}Both the "Total Spacecraft Injection Weight" and the "Launch Escape System Weight" (line G) include the 500 pounds of line F, "Effective Weight, Launch Escape System"; therefore, to avoid counting the 500 pounds of line F twice, the "Total Launch Weight" value of 96,100 pounds in line G is 500 pounds less than the sum of the "Total Spacecraft Injection Weight" and the "Launch Escape System Weight."

e. Reduced propellant residuals.

Grumman Aircraft Engineering Corporation's preliminary "Lunar Excursion Module Mass Properties Report" was received. The weights shown in the report have since increased as a result of more stringent design requirements. Preliminary target weight apportionment has been derived, and results emphasize that strict weight control will be required to insure that the control weight is not exceeded. Results of design studies currently being conducted will refine these target values. The Lunar Excursion Module weight increases shown in table IV result primarily from increased velocity requirements and changed specific impulse values of the ascent and descent engine.

The major Launch Escape System weight changes have been due to the removal of the flow separator, increased amounts of wiring and connectors, and added ballast that is consistent with the combined Service Module and Launch Escape System balance requirements.

North American Aviation, Inc. was requested to review several aspects of the adapter design in an effort to reduce its weight.

The Guidance and Navigation System for the Command and Service Modules has decreased by 35 pounds. This reduction is due to the removal of the rendezvous radar and transponder which have been transferred to the LEM as part of the Guidance and Navigation Subsystem. The current weight of the LEM Guidance and Navigation System was revised by MIT from 250 to 375 pounds. In addition, MIT has proposed an alternate system based on a fixed rather than a scanning telescope. The proposed total weight of the Guidance and Navigation System including the fixed telescope is 244 pounds.

FLIGHT TECHNOLOGY

Aerodynamics

The advisability of retaining the aerodynamic strakes in the present design of the Command Module is in question due to the significant weight penalties and adverse dynamic stability characteristics. The weight penalties result from the increased size of the strakes due to the continued forward movement of the center of gravity and the additional ablator required on the Command Module to combat the increased heating of the strakes during entry. However, the strakes probably could not be removed without necessitating a major redesign of the apex cover jettison system to permit the cover to be jettisoned in the low angle of attack (apex forward) region.

A study is underway to change the test point of Boilerplate No. 22 (high altitude abort) from 180,000 feet to approximately 60,000 feet. Since the original test point selection, additional wind tunnel data and analytical studies have indicated that the lower altitude is more suitable. Primary objective of the test at 60,000 feet would be a determination of Launch Escape Vehicle jet effects on static and dynamic stability and the dynamic stability of the Command Module after tower jettison with the RCS operating.

The major portion of the scheduled Apollo wind tunnel program has been completed, and only five more tests are scheduled for the remainder of 1963. Tests scheduled subsequent to this date will be directed toward the investigation of specific problem areas or as contingency checks on the flight tests. A summary of the wind tunnel program as of June 1, 1963, indicates a total of 37 models have been tested in the facilities of the following organizations:

a. Ames Research Center

b. Arnold Engineering Development Center

c. Cornell Aeronautical Laboratory

d. Jet Propulsion Laboratory

e. Langley Research Center

f. North American Aviation, Inc.

The total wind tunnel occupancy time as of June 1, 1963, was 4,595 hours. North American Aviation, Inc. is completing an aerodynamic data manual which summarizes the aerodynamic force data obtained during the Apollo wind tunnel program. The manual should be published during the next reporting period.

Aerodynamic Heat Transfer

Wind tunnel data at $M = 10$ indicates that the strakes cause significant increases in heating rates on the conical afterbody and necessitate an 87-pound increase in ablation material. Further data and analyses are being obtained to verify this increased heating.

Ablation Material Thermal Performance

Further experimental testing in the alternative heat shield program at North American Aviation, Inc. has been discontinued. Enough physical and mechanical properties tests and thermo-structural analyses were completed so that it was indicated that both the alternative heat shield candidate materials, DC-325 and T-500 would not meet the cold soak environment (-260° F) in their present formulations. North American Aviation, Inc. will prepare during the next quarter a completed summary of the analyses and data obtained in the backup program. Further alternative heat shield efforts will continue within the MSC while North American Aviation, Inc. and Avco Corporation proceed with the primary ablator design, Avco 5026-39 in 3/8-inch fiberglass honeycomb.

A design review of the Scout nose cap program was held at North American Aviation, Inc. Nose cap substructures have been shipped by North American Aviation, Inc. to Avco Corporation for application of the Avco 5026-39 material. Delivery of these caps to Langley Research Center is on schedule. The construction of a second set of caps of DC-325 ablative material has been discontinued as a result of the termination of the alternative heat shield program.

Heat shield material specimens were checked for thermal performance after exposure to ten times the expected Apollo radiation dose. It was found that there was no significant change in thermal performance after radiation exposure.

Mission Natural Environment

The General Motors Corporation/Santa Barbara meteoroid simulation test program has not reached the qualification stage. The major problem is the production of explosive charges which provide the desired velocities. To date, a few charges have been produced which provide velocities up to 14 km/sec; however, difficulties have been encountered in reproducing these velocities. Efforts are continuing to design reproducible charges with the desired velocities.

The dose caused by solar proton radiation at various points in the Command Module is being computed. These calculations are based on the new radiation environment described in terms of the probability of encountering a solar event of a given total number of protons with energy greater than 30 Mev during a 14-day period.

Performance and Trajectories

A characteristic velocity budget has been developed for the Lunar Excursion Module design. The velocity allocation for each mission phase is shown in table V.

TABLE V.- LEM VELOCITY BUDGET

Mission Phase	Characteristic Velocity, fps
Descent Stage	
Equiperiod transfer	380
Powered descent	6,010
Translation and touchdown (approximately 2 sec)	725
Subtotal	7,115
Plus 10 percent reserve	712
Total descent stage requirement	7,827
Ascent Stage	
Launch to intercept[1]	6,025
Midcourse correction	50
Rendezvous[1]	335
Docking	25
Subtotal	6,435
Plus 10 percent reserve	644
Total ascent stage requirement	7,079

[1]Includes ΔV required for 2 degrees out-of-plane launch

RELIABILITY

A study is being made of the common usage parts on the Mercury, Gemini, and Apollo programs in order to minimize the duplication of testing and costs and to utilize the experience accumulated on the Mercury and Gemini programs.

An appraisal is being made of the feasibility of an MSC-Apollo automated data bank which would provide for storage and fast retrieval of reliability and quality data.

Specific recommendations for greater standardization, uniformity, and consistency of the various contractors' reliability and test programs are being prepared in order to achieve an integrated overall Apollo reliability program and to minimize overlapping and duplication of effort in the area of reliability.

Lunar Excursion Module

Grumman Aircraft Engineering Corporation.- The Grumman Aircraft Engineering Corporation reliability plan for the Lunar Excursion Module was submitted during May 1963. The plan is being reviewed for adequacy.

Command and Service Modules

North American Aviation, Inc.- North American Aviation, Inc. continues to refine their earlier prepared reliability analyses on the Command and Service Modules. Included in their latest status reports are crew safety reliability apportionments for the various subsystems.

North American Aviation, Inc. has finalized their qualification test criteria during this quarter for both space vehicle and ground support equipment. Essentially, the qualification criteria are divided into three categories - design proof, off-limit, and mission life.

Studies were initiated by North American Aviation, Inc. on backup capability using LEM equipment. Subsystems for the Command Module and Service Module that may receive either functional or equipment interchange backup from LEM are: electric power, cryogenic storage, environmental control, service propulsion, crew provisions, guidance and control, stabilization and control, telecommunications, and instrumentation.

North American Aviation continues to report that mission success reliability predictions are less than the apportioned reliability values. For example, the environmental control subsystem has a predicted mission success reliability of 0.9805 compared to a 0.997675 reliability apportionment. Added redundancy for the suit compressors and water glycol pumps is expected to be provided so that the apportioned reliability values will be met.

SPACECRAFT-LAUNCH VEHICLE INTEGRATION

Spacecraft-launch vehicle integration includes not only the integration of the spacecraft to the launch vehicle but also the installation of the associated launch and flight control ground support equipment. These activities are accomplished through the following MSC-Marshall Space Flight Center-Launch Operations Center coordination panels. Major accomplishments of the Mechanical Integration Panel, Flight Mechanics Panel, Instrumentation and Communication Panel, Electrical Integration Panel, and Crew Safety Systems Panel are shown in the following paragraphs.

Mechanical Integration Panel

a. It was agreed by MSC and MSFC that air-conditioning barriers are not required on the SA-8 mission.

b. No MSC spacecraft equipment is to extend 100 inches beyond the centerline of the instrument unit on Saturn IB and Saturn V without detail coordination with MSFC.

c. Provisions shall be made for installing the Q-ball on all Saturn C-1 vehicles. Although there are alignment provisions between the Service Module and the Command Module, the requirements for the wedge under the Q-ball will not be deleted at this time.

d. There will be no MSFC requirement for weight and balance ground support equipment for Boilerplate No. 9.

e. MSFC agreed to provide a free volume of 104 inches diameter by 10.5 inches in length in the top center of the instrument unit for Service Propulsion System engine penetration into the instrument unit.

f. The cadmium plating for electrical bonding between the adapter and the instrument unit is acceptable to both MSC and MSFC.

Flight Mechanics Panel

a. MSC and MSFC agreed to implement on June 15, 1963, with their respective contractors, the guidance interface proposed by the Guidance Implementation Sub-Panel if neither center raises an objection prior to that date.

b. MSC will define for the Satrun IB firm attitude, attitude rate, and maneuvers that the S-IVB stage has to achieve while in earth orbit. MSFC will define the payload penalty as a function of attitude control duration in earth orbit for Saturn IB.

c. The Saturn IB will have an earth orbit attitude control capability of $4\frac{1}{2}$ hours using the S-IVB stage. MSC will accept the attitude rate that is available from the S-IVB on Saturn IB flights using the minimum impulse and thrust levels designed for Saturn V. MSFC will use the attitude and maneuver requirements specified for Saturn V earth orbital operations to define the S-IVB Reaction Control System propellant capacity on Saturn IB. The above requirements are considered preliminary dependent on an MSC definition of Saturn IB operations and an MSFC definition of the payload penalty.

d. MSC has no requirement to justify the use of a Q-ball on Saturn I, IB or V research and development or operational flights; however, MSC may utilize the Q-ball for angle-of-attack measurements on the flights that it is used, but MSC would not depend upon its availability.

e. MSC does not require engine-out capability on Saturn I, IB, or V; however, any engine-out capability provided by MSFC will be considered by MSC in developing operational procedures.

Instrumentation and Communication Panel

a. A study was conducted by MSFC on frequency interference problems in the space vehicle. It was determined that no interference problems existed between the radiated frequencies to be used on the spacecraft and the frequencies to be used on the boosters. This study included Saturn I, Saturn IB and Saturn V.

b. MSFC agreed that MSC would use a double pulse code on the spacecraft C-band beacons, and MSFC would continue to use a single pulse. C-band beacon attenna patterns for the spacecraft were submitted to MSFC to determine the adequacy of launch phase tracking using the spacecraft beacons. If the spacecraft beacons prove adequate for launch phase tracking after two or three flights, MSFC will drop the C-band beacon from their Instrument Unit.

c. MSFC has not definitely decided to use the phase-shift keyed digital command system for the S-IVB that is to be used for the spacecraft. But MSFC does plan to use the ground link portion of the MSC digital command system and the command transmitters. A study is being conducted by MSFC to determine the adequacy of the complete spacecraft digital command system for use in commanding the S-IVB stage.

Electrical Integration Panel

a. The Saturn I Instrumentation Unit/Apollo electrical interface for SA-6 and SA-7 has been defined.

b. MSFC/MSC ground support equipment electrical interfaces for Apollo-Saturn have been defined.

Crew Safety Systems Panel

a. A "quick look" type simulation of the Saturn I Emergency Detection System has been completed at Ling-Tempco-Vought, Inc. in Dallas, Texas. A number of comments and suggestions concerning the Emergency Detection System display layout and the types of instruments to be used have been received from individuals participating in the simulation runs. These comments and suggestions will be considered for inclusion in the final display design.

b. The Emergency Detection System design proposed by MSFC is being evaluated by MSC, and comments will be given to MSFC when the review is completed.

MANUFACTURING

COMMAND AND SERVICE MODULES

During this reporting period, a series of meetings have been held between MSC and North American Aviation, Inc. to review in detail the airframe manufacturing program. Production capability and delivery schedules are under evaluation. Present indications are that delays in manufacturing, installation, and testing may require changes to the present ground and flight test program.

Flight Test Articles

Boilerplate No. 6.- The individual systems tests and integrated systems tests were completed for Boilerplate No. 6 on June 28, 1963. Final acceptance tests and preparation for shipping were completed on June 30, 1963.

The boilerplate and its equipment were flown from Long Beach, Calif., to Holloman Air Force Base, N.M., on July 1, 1963, and the shipment was continued by truck the next day to White Sands Missile Range. The check-out trailer and the remaining ground support equipment were shipped by truck from Downey, Calif., on July 1 and 2, 1963.

Boilerplate No. 12.- The command module wiring harness for Boilerplate No. 12 was delivered for installation on July 12, 1963. During this reporting period, the following spacecraft configuration changes have been made to Boilerplate No. 12:

a. Strakes were removed.

b. Hot-wire initiators were substituted for exploding-bridge-wire initiators on the launch escape motor, the tower jettison motor, and the pitch control motor.

c. Two drogue parachutes will be used instead of one.

d. A hot-wire abort initiator system will be substituted for the cold-wire system.

North American Aviation, Inc. has contracted General Dynamics/Convair to install the umbilical for Boilerplate No. 12 on the Little Joe II launcher. The installation will be made at White Sands Missile Range and will take place after the Qualification Test Vehicle launching and before the mating of Boilerplate No. 12 to the launch vehicle.

Boilerplate No. 12 is scheduled to be transferred to North American Apollo Test and Operations at Downey, Calif., during the week of August 5, 1963. The Design Engineering Inspection is planned to be held for this boilerplate before August 12, 1963.

Hardware procurement has become a problem in the manufacturing of Boilerplate No. 12. Critical shortages include miscellaneous nuts and bolts, the C14-019 checkout console, the A14-003 pyro simulator, and the Earth Landing System and Launch Escape System sequencer. All major hardware items are required before tests can begin at North American Apollo Test and Operations, and the items are presently scheduled for delivery by August 5, 1963.

Boilerplate No. 13.- All components, including the breadboard, for the Instrumentation and Communications Systems of Boilerplate No. 13 were shipped to North American Aviation, Inc. during the week of August 5, 1963. At MSC's request, the contracter has installed stiffeners on six of the Service Module ring frames to insure the Service Module's structural integrity during the inflight pressure environment.

North American Aviation, Inc. was directed to hermetically seal all airborne connectors. This action was taken to prevent electrical shortage of the connectors due to water condensation.

The Environmental Control System is being redesigned to operate at a 20° F initial temperature, and to improve the system pressure capability. The coolant tank capacity has been approximately tripled, and the pump outlet pressure has been increased to 10 psig.

The ground support equipment for Boilerplate No. 13 remains the program pacing item. Manufacturing of the boilerplate is scheduled to be completed on August 14, 1963, and it is expected to be ready for shipment to the Atlantic Missile Range on October 1, 1963.

Boilerplate No. 18.- Procurement of instrumentation hardware for Boilerplate No. 18 is scheduled to begin in July 1963.

Ground Test Articles

The primary and secondary structure design and manufacturing planning of Boilerplate No. 14 (House Spacecraft No. 1) was completed during this reporting period. Detail parts and subassemblies are being accumulated in the structural assembly area.

A recent decision to implement three modifications resulted in changes to approximately 30 percent of the secondary structure.

Boilerplate No. 9 (Apollo-Saturn Dynamic Test Article) was mated to the Saturn IV stage, and a shake test was begun at MSFC. To date, no major problems in this area are anticipated or have been reported.

Modifications to Boilerplate No. 25 (Apollo Handling and Transportation Article) have been made to update the boilerplate to the current parachute attach-point configuration. This boilerplate has been reballasted to the present weight and center-of-gravity configuration. Prototype sea retrieval equipment for the Flight Operations Division is available, and several trial retrievals are scheduled during the next quarter.

LUNAR EXCURSION MODULE

MSC is currently evaluating the Grumman Aircraft Engineering Corporation manufacturing plan for Lunar Excursion Modules and LEM test articles. Interim approval of the plan will be given so that tooling manufacturing of early LEM test articles can begin. The interim approval will specify an average production rate of two LEM's every three months. A revision will be requested by September 14, 1963, to include results of further studies on peak production rates and these associated problems:

a. Tooling rate and level

b. Shop loading, considering other Grumman Aircraft Engineering Corporation projects

c. Manufacturing and checkout area requirements.

Management control procedures, analyses of manufacturing operations, and the interchanging of master tools with subcontractors will also be investigated.

Periodic reviews will be scheduled to update the manufacturing plan and cover follow-on tooling changes, schedule changes, specification changes, and modification requirements.

QUALITY ASSURANCE

The first LEM hardware specifications were reviewed to insure that the development, qualification, and acceptance test programs generate reliability data.

The overall documentation status of all Apollo contractors was checked to see if the contractors have been submitting required documents according to contract deadlines.

Direction was given to Government Inspection Agencies to comply with the requirements of NASA Management Manual Instruction 4-3-2 for the use of quality status stamps. Stamps for use as directed by Instruction 4-3-2 have been issued to each agency.

A standard failure effects analysis format was generated and sent to all Apollo contractors to facilitate better analyses of failure data from all sources.

During this reporting period, efforts were begun to develop a set of standardized process specifications for use by all Apollo contractors. The first result of this effort was that soldering specification MSFC-PROC-158 B was invoked in all major Apollo contracts. An identification and traceability procedure was prepared for use by all Apollo contractors and sent out for review and comment. Standard process specifications were developed for crimping electrical connectors and splicing electrical conductors.

The Grumman Aircraft Engineering Corporation quality control program plan for the LEM was submitted during May 1963. The plan has been evaluated and is considered satisfactory for use.

The Bureau of Weapons Representative/Bethpage delegation for inspection services was clarified in an agreement dated May 17, 1963. Basically the delegation limits the BuWeps Representative to hardware inspection while the Resident Apollo Spacecraft Project Office retains quality engineering responsibilities.

SIMULATORS

ENGINEERING SIMULATION PROGRAM

Command and Service Modules

Much effort at North American Aviation, Inc. has been spent on detailed planning of the engineering simulation program through 1965. The first issue of the complete plan will be published during the next quarter. At the present time, nine simulations are in progress. The majority of these are unmanned simulations with the exception of two. A manned simulation of rendezvous is currently being conducted, and a second manned simulation of entry is about to begin.

Lunar Excursion Module

Grumman Aircraft Engineering Corporation has presented their engineering simulation program plan to MSC. This plan calls for using existing Grumman Aircraft Engineering Corporation facilities in addition to contracted facilities at North American Aviation/Columbus and Ling-Temco-Vought, Inc. through 1964. Two part-task simulators will become operational at Grumman Aircraft Engineering Corporation early in 1964, and a complete mission simulator will be available early in 1965. MSC has approved a Grumman Aircraft Engineering Corporation proposal to procure two virtual image visual display systems for use in the part-task engineering simulators and the complete mission simulator. These would be transferred to the LEM trainers when they become operational in 1965.

A preliminary docking study was completed by Grumman Aircraft Engineering Company at North American Aviation/Columbus in April 1963. MSC completed a LEM docking simulation with a backup type control system. These studies have resulted in lowering the docking design criteria limits to the contact conditions shown in the following table.

Axial Velocity	1 fps
Radial Velocity	.5 fps
Angular Velocity	1 deg/sec
Angular Displacement	10 deg
Radial Displacement	1 ft

The relative velocities are measured at the center of gravity of the vehicle.

MSC completed a manual abort study at Ling-Temco-Vought, Inc. The results of the study indicate that a pilot can perform an abort from any point in the LEM descent trajectory with only very simple information, such as vehicle attitude and time, displayed to him. The addition of further information such as altitude and altitude rate greatly increases the accuracy with which insertion to rendezvous can be made, and more information also increases the probability that abort can be completed with the available amount of fuel.

MISSION SIMULATORS

The Link Division of General Precision, Inc. was selected as the subcontractor for the Apollo mission simulator. The letter contract was awarded April 10, 1963.

Link held a mockup review of the Apollo mission simulator complex at its plant in Binghampton, New York, on June 14 and 15, 1963. A number of modifications of the details in the instructor's consoles were suggested.

The critical path for the mission simulator PERT chart is the infinity image visual simulation system for the windows. The major elements of this system are being procured from Farrand Optical Company, Bronx, New York.

LUNAR EXCURSION MODULE FREE-FLIGHT SIMULATORS

In mid-April 1963, Grumman Aircraft Engineering Corporation presented a summary of their efforts concerning the conceptual design of free-flight vehicles for atmospheric test (LTA-9). Included with the summary were recommendations for a preliminary design phase. As a result of this summary, Grumman Aircraft Engineering Corporation was directed to commence the preliminary design phase of LEM atmospheric flight vehicles for hover and landing tests and for gaining operational flight experience. During this phase, firm technical, schedule, cost, and manpower information will be developed in the following areas:

a. Minimum modification and usage of an all-rocket LEM for atmospheric test and flight experience in restrained, tethered, and free-flight modes

b. Integration with LEM ground and flight test programs

c. Investigation of the use of LEM subsystems or design data and technology in the lunar landing programs at the Flight Research Center (Edwards Air Force Base) and Langley Research Center to increase their fidelity and applicability for LEM development.

This preliminary design phase is scheduled to be completed by July 15, 1963, except for that portion pertaining to the Flight Research Center's Lunar Landing Research Vehicle (LLRV) Program which was completed May 15, 1963. A Grumman Aircraft Engineering Corporation Report LED 470-2, "Application of LEM Technology to NASA Lunar Landing Research Program," recommends the application of the LLRV to the LEM Development Program in the following three areas:

a. Early verification of LEM systems analysis and design decisions

b. Use of the LLRV for LEM hardware testing

c. Use of the LLRV for free flight experience in a LEM-type vehicle.

OPERATIONS

SPACECRAFT CHECKOUT

The definition of Special Test Units was established as those items of checkout equipment which are configured for a specific need but which are not items of program automatic checkout equipment (PACE). Malfunction isolation capability will be the replaceable black box for electronics or the smallest replaceable package for mechanical systems.

PACE-spacecraft checkout with Airframe No. 008 is planned to be used at the MSC environmental facility.

PACE-spacecraft operational functions, hardware interfaces, and test point requirements have been further defined. An Apollo vehicle measurements list for Airframe No. 009 which lists and defines airframe test points has been published.

Contractors have been given a MSC document which establishes PACE-spacecraft checkout programing and operation at MSC contractors' plants in addition to establishing a format for the conversion of test sequences into machine language.

The basic handling concept for Boilerplate No. 13 was established in detail. The testing and operation of airframes at the Atlantic Missile Range has been established for the Command and Service Modules.

PREFLIGHT

The development of PACE-spacecraft checkout now provides for the initial use of a ground station at North American Aviation, Inc. in support of systems testing of an airframe on March 15, 1964. Initial use of the ground station at Grumman Aircraft Engineering Corporation is scheduled for March 1965.

GROUND TEST PROGRAM

COMMAND AND SERVICE MODULES

Airframe 008

Additional floor space for the offices of North American Aviation, Inc. and Massachusetts Institute of Technology at the MSC Clear Lake facility near Houston, Texas, has been approved. PACE will be used for checkout and operation at the Clear Lake facility. An MSC review of Airframe No. 008 testing that constrains the flight of No. 009 indicated that Airframe No. 008 tests would not be required. The instrumentation plan for the Clear Lake facility is being reviewed and should be completed during the next reporting period.

LUNAR EXCURSION MODULE

The ground test vehicles to be used in the LEM ground test program are designated as LEM Test Articles (LTA's). Table VI lists the vehicles and their purposes.

TABLE VI.- LEM TEST ARTICLES AND THEIR PURPOSES

Article	Purpose	Testing Organization	Test Starting Date
LTA-1	Systems integration	GAEC	Aug 64
LTA-2	Drop tests/booster dynamic tests	GAEC/MSFC	Dec 64
LTA-3	Structural tests	GAEC	Dec 64
LTA-4	Environmental development	GAEC	Apr 65
LTA-5	Propulsion qualification	WSMR	June 65
LTA-6	Apollo integration	NAA	May 65
LTA-7	Environmental qualification	MSC	Nov 65

Plans for the propulsion test program and facilities were made definite during this reporting period.

LEM propulsion system testing is scheduled to start at White Sands Missile Range in July 1964 on a prototype vehicle designated as the P-5 Rig. The initial testing will be developmental work on the Ascent and Descent Propulsion Systems. These tests will be followed by propulsion system qualification and LEM system integration and qualification (LTA-5).

It is currently planned for the White Sands Missile Range propulsion facility to consist of two altitude stands and one ambient stand with a diffuser. The ambient stand will be designed for potential conversion to an altitude stand at a future date.

Two additional articles, LTA-8 and LTA-9, are contracted for, but their exact use and configuration are subject to evaluation based on a study to be completed by Grumman Aircraft Engineering Corporation by July 15, 1963. These vehicles are currently being proposed for atmospheric hover and landing tests at White Sands Missile Range.

GROUND SUPPORT EQUIPMENT PROGRAM

COMMAND AND SERVICE MODULES

All the major items of Ground Support Equipment (GSE) that support Boilerplates No. 6, 12, and 13 have been checked for technical adequacy at design reviews held during this reporting period. Of the 161 models reviewed, changes were recommended on 55. Some of the most significant changes were:

a. Redesign of H14-9030, support, Service Module, and adapter, to accept the completely mated spacecraft for checkout at Downey, Calif.

b. Request for a study on the shielding and ground of C14-177, cable set, Pad 37B, to determine ground loop potential

c. Modification of A14-001, General Electric Company tower substitute unit, to simulate strain gage measurement. Ordinarily, instrumentation will not be simulated in substitute units; however, this is a special case since the associated amplifier is in the Command Module.

The North American Aviation Inc., Special Test Units (STU) management plan was reviewed. The plan indicated that North American Aviation, Inc. and its Autonetics Division would do a major part of the design and manufacturing. The present schedule shows that this equipment is approximately $2\frac{1}{2}$ months behind schedule due to the lack of flight systems definitions. The STU's will be used at Downey, White Sands Missile Range, and Atlantic Missile Range. At present, this equipment is not scheduled for use with Airframe No. 008 tests in Houston.

A study is being made to include LEM hypergolic servicing equipment requirements in equipment furnished by North American Aviation, Inc.

The GSE required to support Boilerplates No. 16 and 26 at MSFC and the Atlantic Missile Range was established. Directions were given to North American Aviation, Inc. to design and fabricate the additional GSE required.

Design of the spacecraft instrumentation test equipment, C14-405, is almost 80 percent complete.

LUNAR EXCURSION MODULE

A preliminary LEM GSE plan has been prepared which contains the following provisions:

a. A summary and purpose of all documents related to GSE

b. PERT implementation, including a discussion of various PERT reports

c. GSE environmental categories and the environment in which all facilities and locations are categorized

d. GSE environmental test requirements and procedures

e. Purpose and definition of the Operational Flow Chart

f. Ground rules for common usage implementation

g. GSE traceability requirements

h. A total implementation plan.

Grumman Aircraft Engineering Corporation has completed the first level of detail for the Operational Flow Chart, which pictorially presents major phases of LEM activity from beginning of manufacturing to launch, and lists GSE required to support each activity. The chart is being expanded to show detailed handling of the LEM and LEM systems, and also to show the checkout and servicing of GSE in its final location.

This effort will aid in the definition of the total LEM GSE program and will show the use of each GSE item in the overall sequence prior to designing and manufacturing the item.

FLIGHT PROGRAM

SATURN

The Project Apollo Mission Schedule is shown in figures 10 through 13. Mission objectives and configuration data for Project Apollo flights using the Saturn I launch vehicle are being determined and should be completed by the next Quarterly Status Report. The Saturn I flight program now consists of the following:

a. Two boilerplate spacecraft for launch environment and Launch Escape System characteristics

b. One airframe spacecraft unmanned suborbital Command and Service Module systems and water recovery qualification prior to the first manned flight

c. Three airframe spacecraft for manned orbital flight with both water and land recovery.

In addition, two boilerplate spacecraft will be made available to MSFC for micrometeoroid experiments. Subsequent flight mission objectives and configurations using the Saturn IB and V launch vehicles are being defined. A tentative program utilizing these vehicles is reflected in figures 12 and 13. The use of Boilerplate No. 18 with an airframe Service Module and adapter is being studied. This boilerplate is to be used for Service Module and adapter structural qualification tests and for evaluation of spacecraft separation from the launch vehicle.

MICROMETEOROID EXPERIMENTS

MSFC is receiving boilerplate hardware requested from MSC. Secondary objectives of Project Apollo will be the Emergency Detection System checkout and normal tower jettison.

Boilerplate 15 will be configured for the launch exit environment mission on SA-7 to obtain a second data point. The flight plan and mission objectives are as defined for Boilerplate No. 13.

COMMAND AND SERVICE MODULES

Boilerplate No. 6

Boilerplate No. 6 arrived at White Sands Missile Range on July 2, 1963, by truck after it was flown from Long Beach, California to Holloman Air Force Base, New Mexico. Thirty-three working days have been scheduled for prelaunch activities for this boilerplate at White Sands Missile Range. Prelaunch activities which are complete or which are to be completed include the following:

a. The second revision of the Pad Abort Mission Directive has been published and distributed.

b. The Command Module is in receiving inspection. Work stands are being assembled around the Command Module.

c. The launch escape motor is ready to be painted for photographic coverage. Striping and painting are to be completed by midnight, July 10, 1963.

d. The weight and balance equipment is scheduled to be ready to accept the spacecraft by July 15, 1963, providing that the weighing lists can be calibrated by then.

e. The checkout trailer receiving inspection is in process. Although considerable equipment has been removed for calibration, the trailer is expected to be ready to support testing by July 24, 1963.

f. The launch complex is expected to be ready to accept the spacecraft July 19, 1963.

Boilerplate No. 12

Nine weeks of prelaunch activities at White Sands Missile Range are presently scheduled for Boilerplate No. 12. A hot wire abort initiation system will be utilized for this boilerplate. The first revision to the mission directive is in progress.

Boilerplate No. 13

The mission directive for Boilerplate No. 13 is in the final stages of preparation and should be completed during the next reporting period. This boilerplate is scheduled to be delivered to the Atlantic Missile Range on October 1, 1963, to support a launch date of December 15, 1963.

LAUNCH ENVIRONMENT

The first launch exit environment test will be made with Boilerplate No. 13. The spacecraft will be launched on SA-6 from Complex 37B at a launch azimuth of 90°; the roll program will provide a flight azimuth of 105°. The escape tower will be jettisoned 10 seconds after S-IV ignition. The S-IV, the adapter, and the Command and Service Modules will be placed in a 100-nautical-mile orbit. No recovery is planned. Objectives of this flight are as follows:

a. Qualify the launch vehicle

b. Demonstrate the physical compatibility of the launch vehicle and spacecraft under flight and preflight conditions

c. Determine the launch and exit environmental parameters to verify design criteria

d. Demonstrate satisfactory separation of the launch escape tower

e. Demonstrate compatibility of the Research and Development Communication and Instrumentation Systems with the launch vehicle systems

f. Determine operational suitability of the Atlantic Missile Range ground tracking systems.

Airframe No. 009

The decision has been made that the mission for Airframe No. 009 will be suborbital. Systems requirements, instrumentation requirements, and details of the mission are now in review.

SPACECRAFT QUALIFICATION

Airframe No. 009 is to be an unmanned suborbital mission to qualify the spacecraft for manned orbital flight. The spacecraft will be launched from Complex 34 at a launch azimuth of 100° with the roll program providing a flight azimuth of 105°. The escape tower will be jettisoned 10 seconds after S-IV ignition, and the spacecraft will separate from the S-IV at burnout at an altitude of approximately 100 nautical miles. Two firings of the Service Propulsion System are planned prior to separation of the Command Module from the Service Module. A water recovery of the Command Module off Ascension Island is planned. Flight objectives are as follows:

a. Qualify the heat protection system at suborbital reentry conditions

b. Determine the satisfactory operation of the Service Module Propulsion System at zero g for subsequent de-orbit capability

c. Determine satisfactory operational characteristics of the Command and Service Module systems

d. Demonstrate satisfactory recovery operational techniques

e. Demonstrate adequate compatibility of the production Command and Service Modules with the C-1 launch vehicle, including the Emergency Detection System.

STRUCTURAL QUALIFICATION

A proposed mission under study for Boilerplate No. 18 is to qualify the adapter and Service Module structures and the spacecraft-launch vehicle separation systems. The spacecraft will be launched from Complex 37B at a launch azimuth of 90°; the roll program will provide a flight azimuth of 72°. The escape tower will be jettisoned 10 seconds after S-IV ignition, and the spacecraft will separate from the S-IV at burnout. Spacecraft orbit will be 100 nautical miles, and no recovery is planned. Flight objectives are as follows:

a. Demonstrate the structural integrity of the production adapter and Service Module structure for flight loads to be encountered on manned Saturn I flights

b. Evaluate the separation sequence and physical separation of the Command and Service Modules from the launch vehicle.

PAD ABORT AND LITTLE JOE II

Pad Abort Test No. 1 (Boilerplate No. 6) has been slipped to August 25, 1963, due to late design changes and checkout difficulties. The first Little Joe II launch vehicle qualification test flight, expected about September 15, 1963, will follow Pad abort Test No. 1 as closely as possible (see fig. 10).

The other pad abort and Little Joe II flights have been rescheduled due to a slippage in the deliveries of the Command Modules and Little Joe launch vehicles for these tests. Problems encountered during Little Joe II checkout resulted in a delay in delivery of the launch vehicle to White Sands Missile Range. This delay prevented consideration of Qualification Test Vehicle flights prior to Pad Abort Test No. 1. The abort capability and recovery system for the Command Module will have been demonstrated with Boilerplate No. 12, making it possible to recover Boilerplate No. 22 in the event the launch vehicle Attitude Control System fails. Because of this proven abort capability, the launch vehicle will be used as a backup for the High Altitude and High Q Abort Test No. 2 flights.

LITTLE JOE II LAUNCH VEHICLE DEVELOPMENT

The first Little Joe II launch vehicle final systems tests are being conducted prior to the launch vehicle's shipment to White Sands Missile Range. Shipment to White Sands Missile Range in early-July 1963 is anticipated, and the qualification test is scheduled for September 1963. A two-week delay has been required to make design changes in the instrumentation system. A sketch of the vehicle on the launcher with the dummy payload is shown in figure 9. The manufacture of the airframe and fins of the second vehicle for the initial spacecraft flight has been completed. The installation of motor ignition wiring circuits has been delayed until design changes initiated by a Design Engineering Inspection of the first vehicle are completed; but the delay is not expected to affect the schedule. The third vehicle (backup for Boilerplate No. 12 flight) is nearly complete in the final assembly fixture. Manufacture of the thrust bulkhead and components for the fourth vehicle is in progress.

The contract has been completed with General Dynamics/Convair for two launch vehicles with control systems (vehicles No. 5 and 6).

Assembly of the launcher on the pad at White Sands Missile Range has been completed, and the launcher has been functionally operated. The spare launcher has been manufactured and will remain at General Dynamics/Convair until required.

The Algol and Recruit rocket motors for the first vehicle have been delivered to White Sands Missile Range. Two of three Algol motor static firings to develop and qualify the canted nozzle for vehicles No. 5 and 6 have been successfully conducted. A third static firing is scheduled for July 1963.

The ground support equipment for rocket motor handling and check out has been delivered to White Sands Missile Range. The ground support equipment for the launch vehicle will be shipped with the first vehicle.

FACILITIES

COMMAND AND SERVICE MODULES

The status of industrial facilities at Downey, California, is as follows:

a. Completed and in operation:

   1. Impact test facility
   2. Plaster master facility
   3. Radiographic facility
   4. Parking lot, part I
   5. Bonding and test facility
   6. Building One modification

b. Design work completed:

   1. Data ground station
   2. Building Six modification
   3. Parking lot, part II
   4. Systems integration and checkout facility
   5. Space systems development facility, parts I and II

c. Contract awarded and construction in progress:

   1. Building Six modifications
   2. Systems integration and checkout facility
   3. Space systems development facility, parts I and II

The El Centro, California, facilities are complete and in operation.

Formal facilities contracts were awarded to Minneapolis-Honeywell Regulator Company, Beech Aircraft Company, and Collins Radio Company. Avco Corporation's contract is being reviewed by NASA Headquarters. The Pratt and Whitney Aircraft Division contract is being negotiated.

At White Sands Missile Range, N.M., the pad abort operational ready need date is July 7, 1963, with the scheduled completion date of July 24, 1963.

The Little Joe II operational ready need date to support Boiler-plate No. 12 is mid-October 1963, with the scheduled completion date of November 15, 1963.

Need dates and completion dates for installations at the Test Stand No. 1 Complex at White Sands Missile Range are shown in the following table.

TABLE VII.- TEST STAND NO. 1 COMPLEX, WSMR

Construction	Need Date	Completion Date
Control room (Joint occupancy)	Sept. 1, 1963	Sept. 11, 1963
Service Module test stand (Joint occupancy)	Sept. 1, 1963	Sept. 17, 1963
Service Module test stand (Operational ready)	Nov. 1, 1963	Dec. 9, 1963
Preparation building (Joint occupancy)	Mar. 15, 1964	Jan. 1[illegible], 1964
Command and Service Modules test stand (Joint occupancy)	Apr. 15, 1964	Feb. 15, 1964
Administrative area (Completion of construction)	Feb. 20, 1964	Feb. 6, 1964

LUNAR EXCURSION MODULE

White Sands Missile Range Facilities

A committee consisting of representatives from White Sands Missile Range, Corps of Engineers, Grumman Aircraft Engineering Corporation, and MSC has been formed to oversee the LEM test facility design contracted to Burns and Roe, Inc.

Three test stands, a preparation building, a warehouse, and administrative buildings will be provided. Two of the test stands will have high-altitude firing capability. The remaining test stand will be designed for ambient firing conditions with provisions to add altitude capability at a later date. Design and construction of the test stands are scheduled to be completed by mid-October 1963 and July 1, 1964, respectively.

Grumman Aircraft Engineering Corporation Facilities Plan

The Grumman Aircraft Engineering Corporation facilities plan was received July 11, 1963, and an interim approval was given with an August 15, 1963, revision date. Variations in manufacturing and test areas, coupled with space requirements by Massachusetts Institute of Technology and General Electric Company, will cause changes to the plan. Grumman Aircraft Engineering Corporation is submitting their facility requirements to the Atlantic Missile Range in early July 1963 for discussion and resolution. The August 15, 1963, revision can be specific in all areas.

PROGRAM EVALUATION AND REVIEW TECHNIQUE (PERT)

Grumman Aircraft Engineering Corporation is scheduled to complete all 12 LEM subsystem networks by July 15, 1963. Additionally, a separate network (some 20 total) oriented to the delivery of each major end item of hardware is planned. Two networks, the Stabilization and Control System and the Reaction Control System subnetworks, have been satisfactorily developed and implemented. As a means of expediting the selection of milestones and developing networks, a series of meetings are being held with Grumman Aircraft Engineering Corporation, the Apollo Project Office and PERT personnel.

The program management plan milestone reporting system was terminated June 1, 1963. The PERT system is functioning satisfactorily.

The North American Aviation, Inc. PERT system has been implemented. Work is underway to include the Office of Manned Space Flight milestones in the PERT networks. North American Aviation, Inc. is adding and restructuring networks to conform with a new general order structure. A July 5, 1963, report date is scheduled for the new network structure.

PUBLICATIONS

The following papers relative to PROJECT APOLLO have been received during the last 3 months:

1 "Apollo Guidance And Navigation. A Progress Report On The Apollo Guidance System," MIT: Dec. 1962, NAS 9-153.

2. "Apollo Guidance And Navigation. Inertial Orientation Of The Moon," MIT: Oct. 1962, NAS 9-103.

3. "Apollo Guidance And Navigation. Earth Orbital Rendezvous," MIT: May 1962, NAS 9-153.

4. "Apollo Guidance And Navigation System Reliability Apportionments And Initial Analysis," MIT:Feb. 1963, NAS 9-153.

5. "Martin Landing Studies: Launch Vehicle," Martin Co.: Mar. 1962, ER-12301.

6. "Martin Lunar Landing Studies: Docking Techniques," Martin Co.: Mar. 1962, ER-12302.

7. "Martin Lunar Landing Studies: Radiation Exposure Analysis," Martin Co.: Mar. 1962, ER-12299.

8. "Martin Lunar Landing Studies: Reliability," Mar. 1962, ER-12296.

9. "NASA System Design And Research," MIT: June 1-July 31, 1962; Oct. 1-Nov. 30, 1962; Dec. 1, 1962-Jan. 31, 1963, NAS 9-105.

10. "Project Apollo Guidance And Navigation Program," MIT: July 18-Aug. 21, 1962; Sept. 11-Oct. 11, 1962, NAS 9-153.

11. "Site Data Processor - Output Buffer," MIT: Dec. 11, 1962, NAS 9-105.

12. "Studies Of Lunar Logistics System Payload Performance," Grumman Aircraft Engineering Corp.: Vol. I, Sections 1-6, Jan. 7, 1963; Vol. II, Sections 7-13, Jan. 3, 1963; Vol. II, Jan. 7, 1963; Supplement 1, Feb. 14, 1963, NASw-528; PDR-344-36.

13. "Study Of Spacecraft Bus For Lunar Logistics System," Space Technology Labs, Inc.: Vol. II, Part A, Dec. 22, 1962, NASw-530.

14. "Wind-Tunnel Measurements Of Some Dynamic Stability Characteristics Of 0.055-Scale Models Of Proposed Apollo Command Module And Launch-Escape Configurations At Mach Numbers From 2.40 to 4.65," NASA: Mar. 1963, NASA TM X-769.

COMMUNICATION AND INSTRUMENTATION

15. "Common Usage Status, LEM Communications Subsystem," Grumman Aircraft Engineering Corp.: March 18, 1963, LED-380-1.

16. "LEM Instrumentation Subsystem Common Usage Study," Grumman Aircraft Engineering Corp.: March 18, 1963, LED-360-1.

17. "Preliminary Environmental And Load Conditions For LEM Scientific Instrumentation," Grumman Aircraft Corp.: LED-360-3.

ENVIRONMENTAL CONTROL SYSTEM

18. "Design Analysis on Utilizing PLSS Cartridges in LEM ECS," Grumman Aircraft Engineering Corp.: Revision B April 26, 1963, LED-330-2.

19. "Design Control Specification for LEM Environmental Control Subsystem," Grumman Aircraft Engineering Corp.: Sections 1, 2, 3, and 4, April 22, 1963, LSP-330-2.

20. "Vendor Resuirements-ECS," Grumman Aircraft Engineering Corp.: Sections 1, 2, 3, and 4 for the LEM, April 22, 1963, LVR-330-2.

ELECTRICAL POWER SYSTEM

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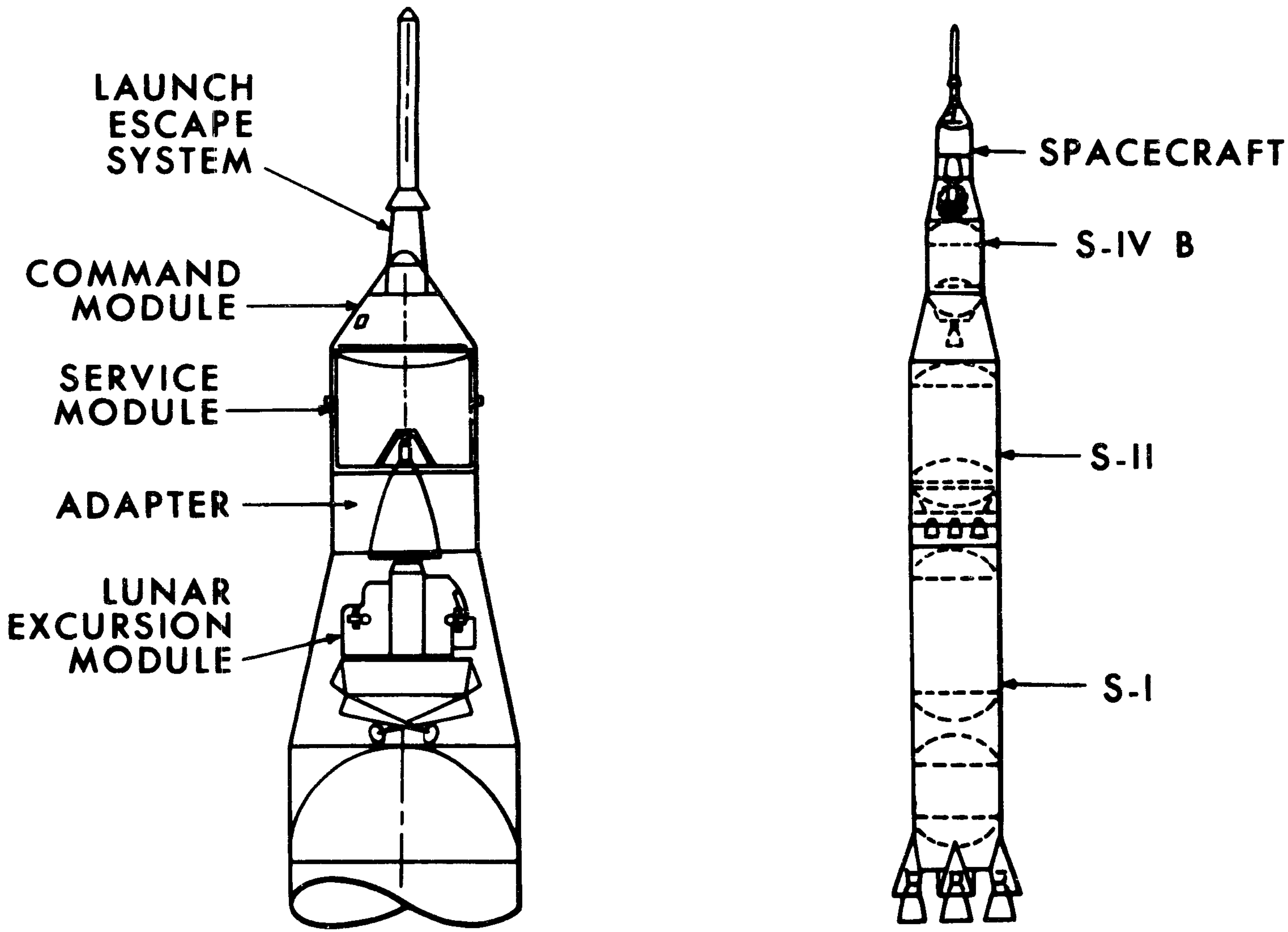

Figure 1.- Apollo Space Vehicle Configuration

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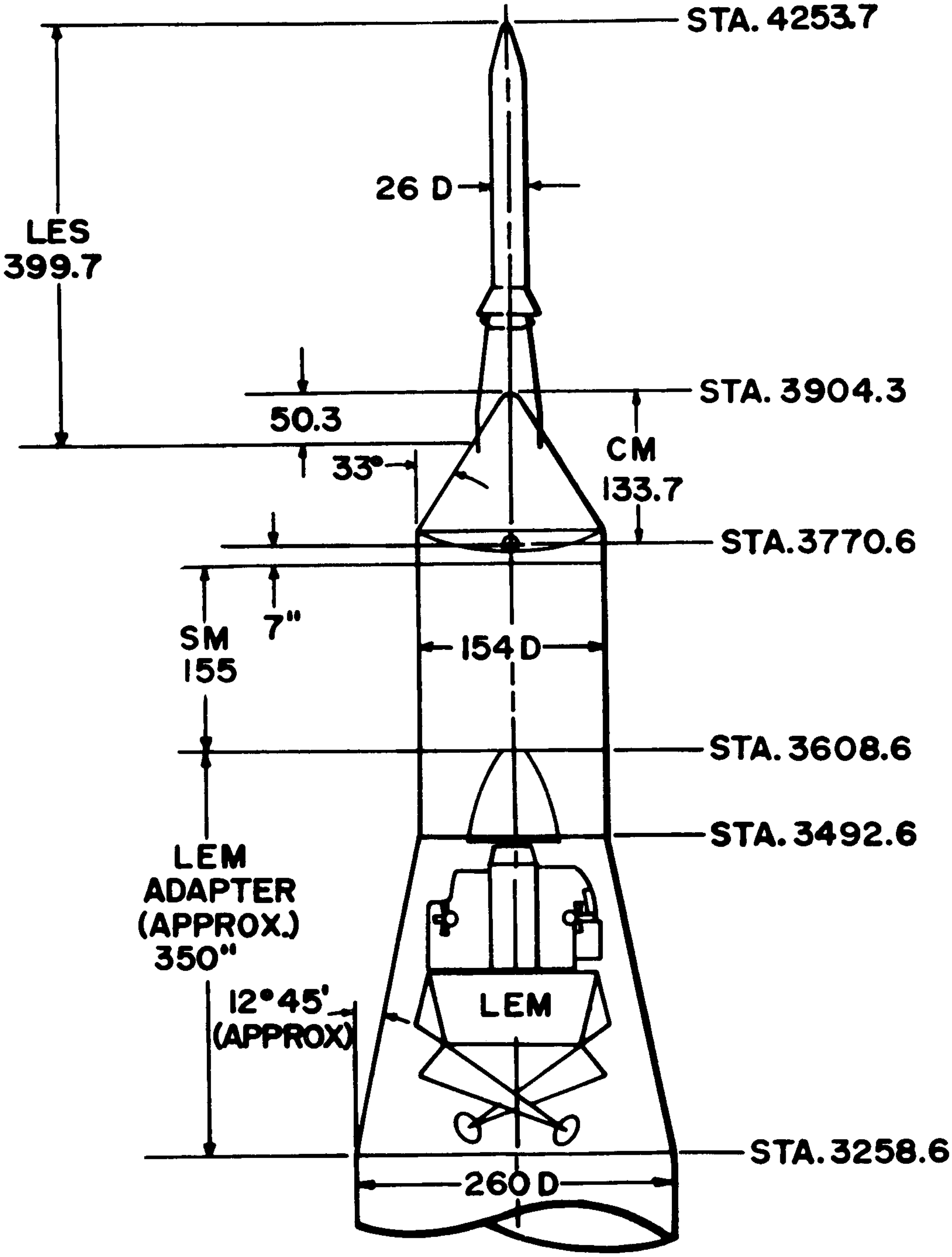

Figure 2.- Apollo Spacecraft Configuration

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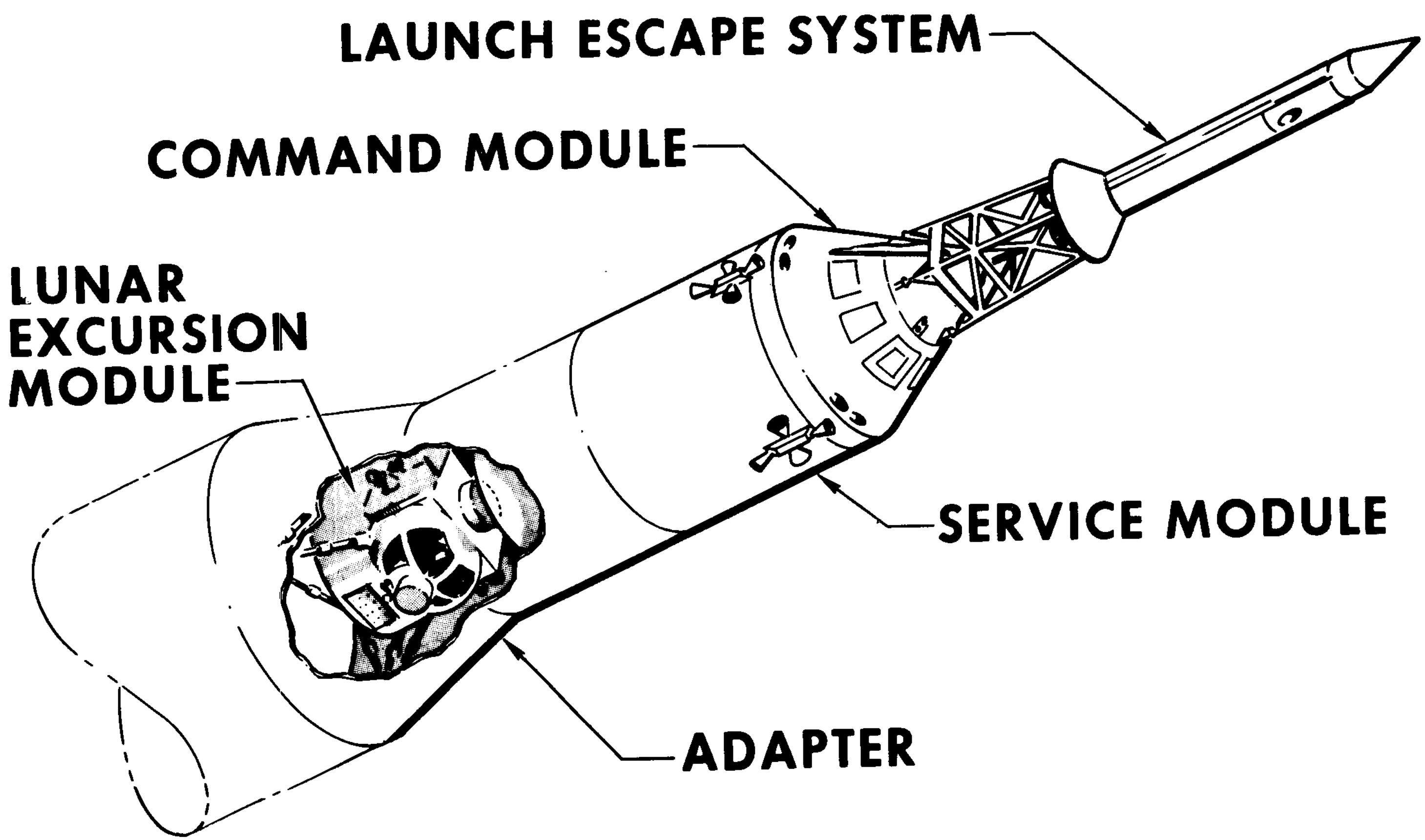

Figure 3. - Apollo Spacecraft

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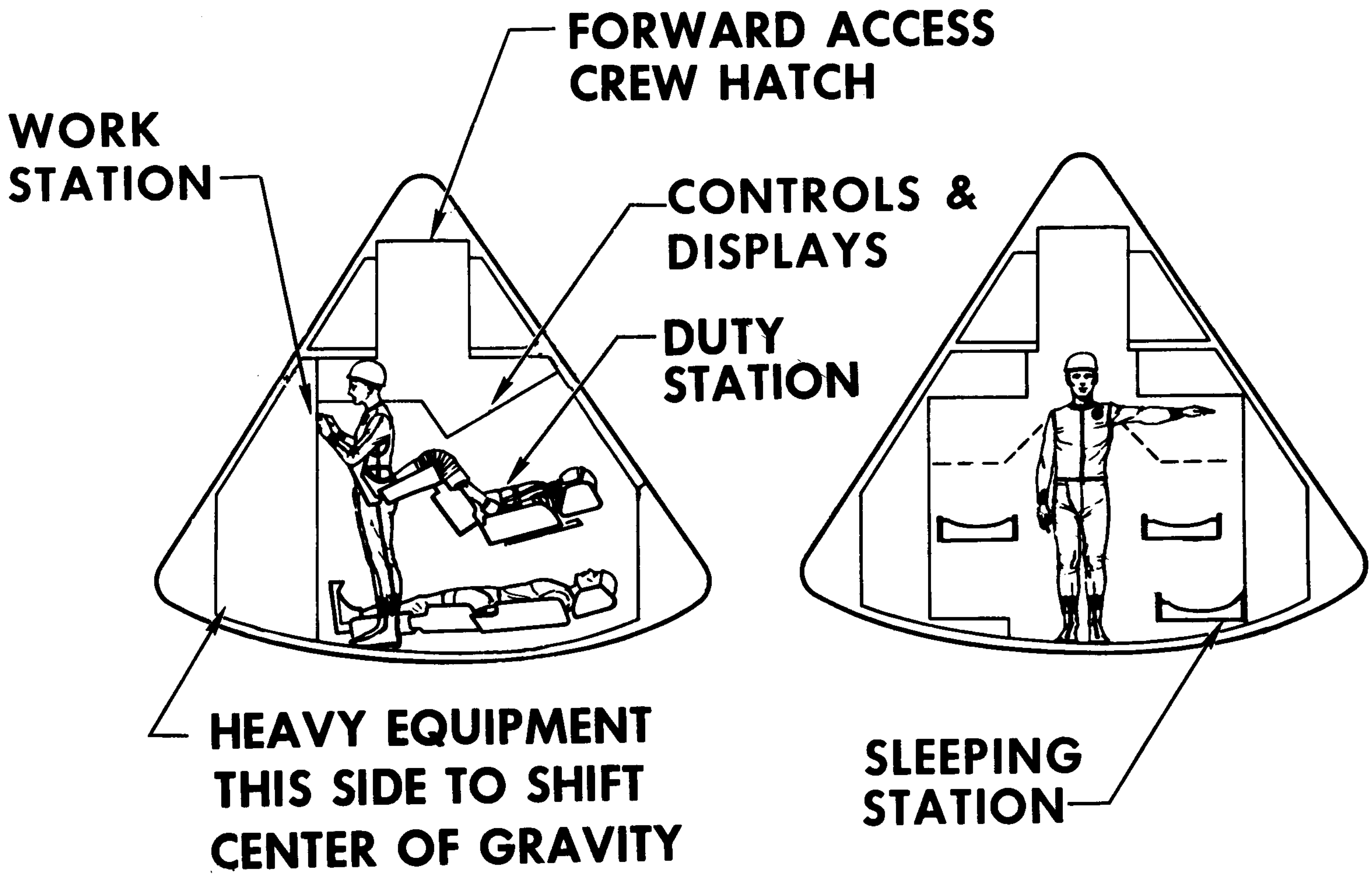

Figure 4.- Command Module

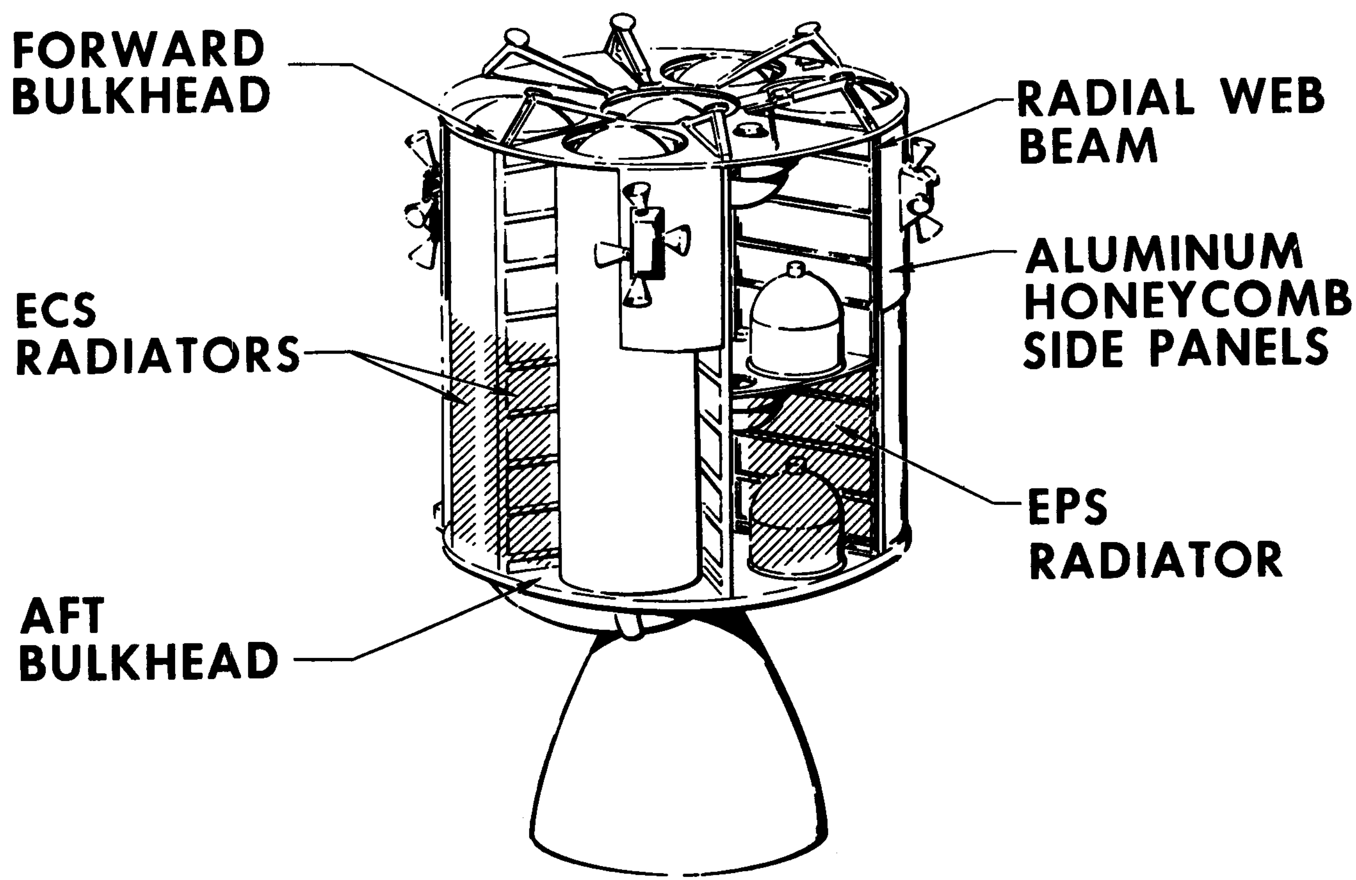

Figure 5.- Service Module

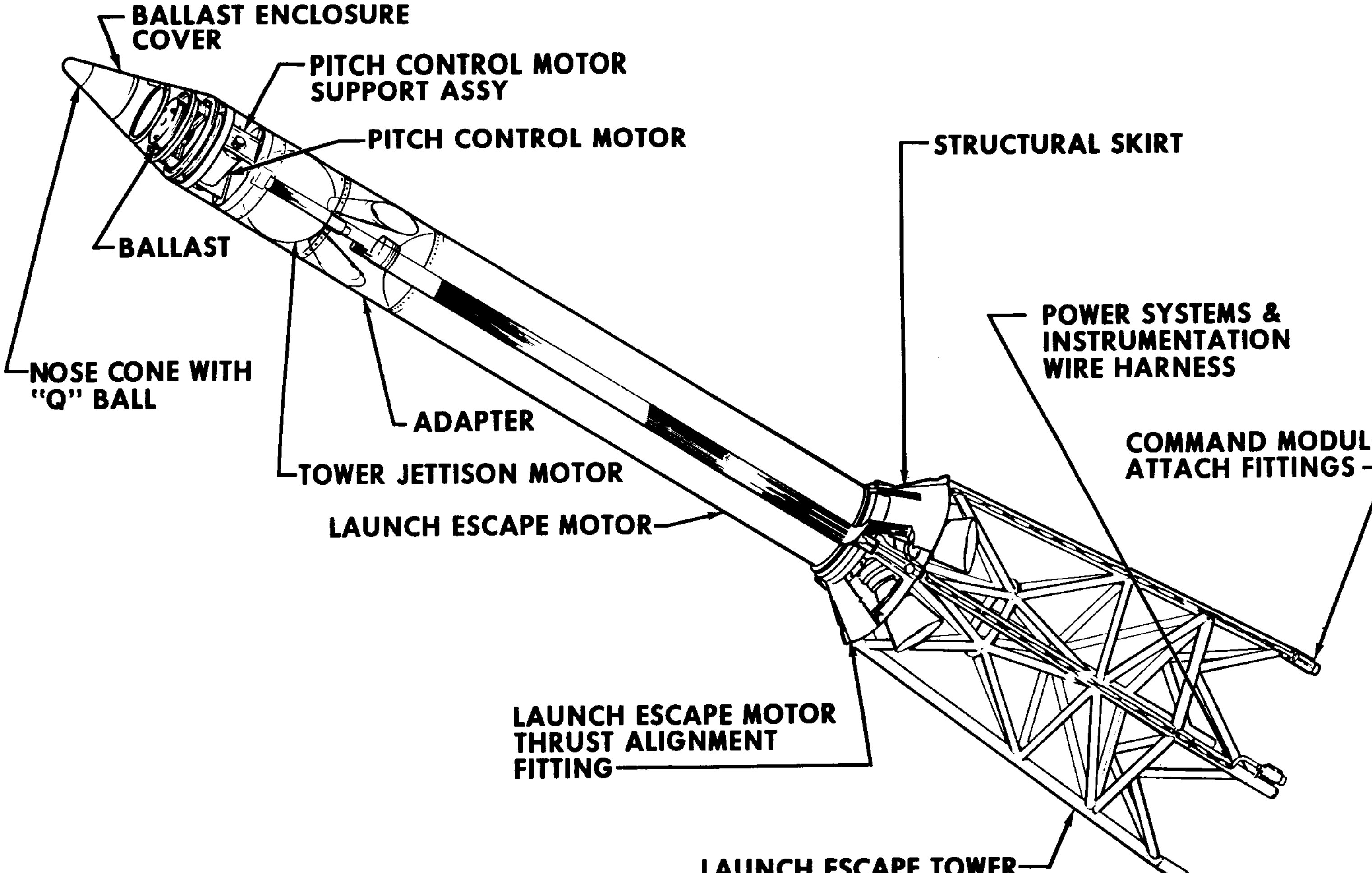

Figure 6.- Launch Escape System

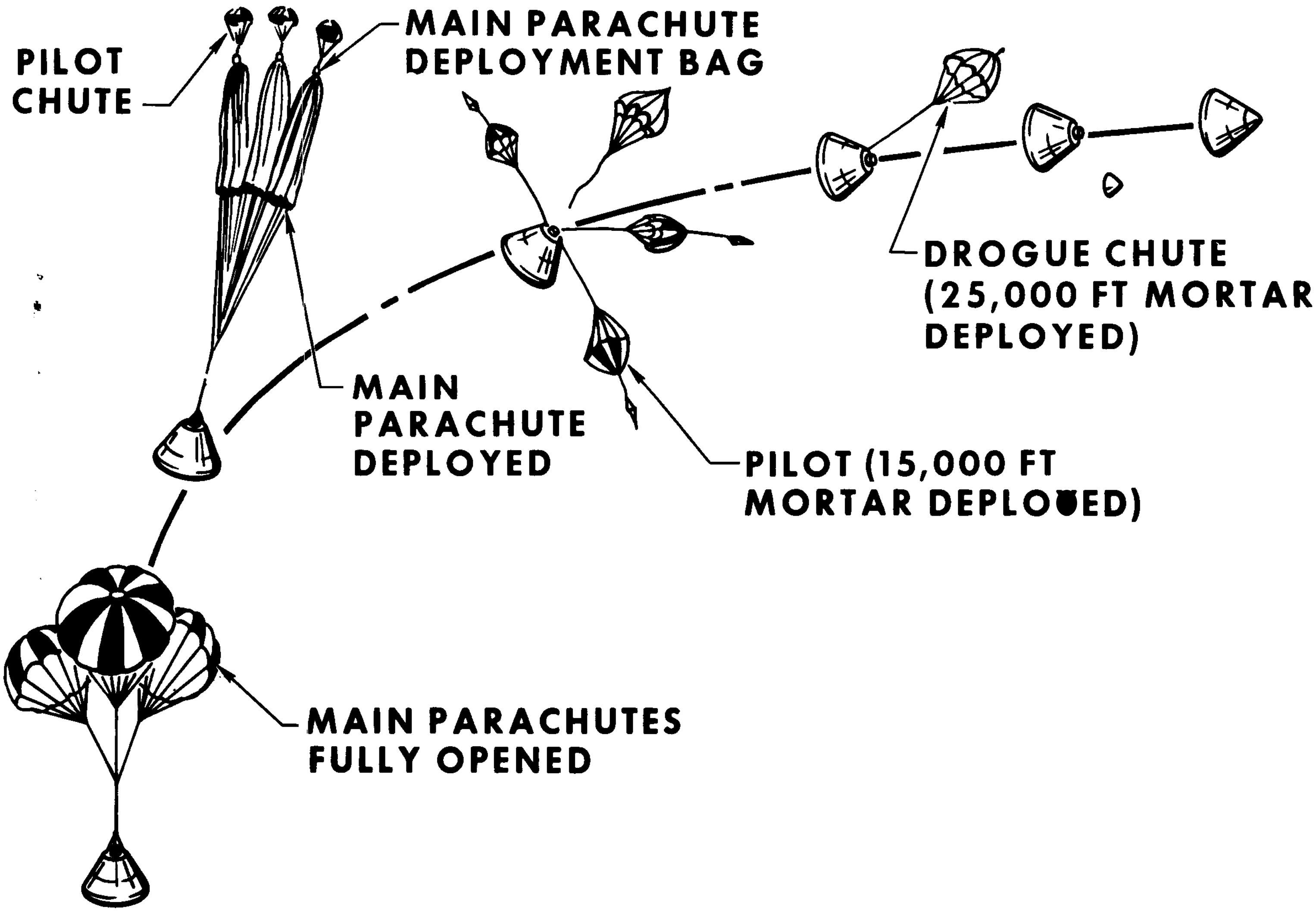

Figure 7.- Earth Landing System

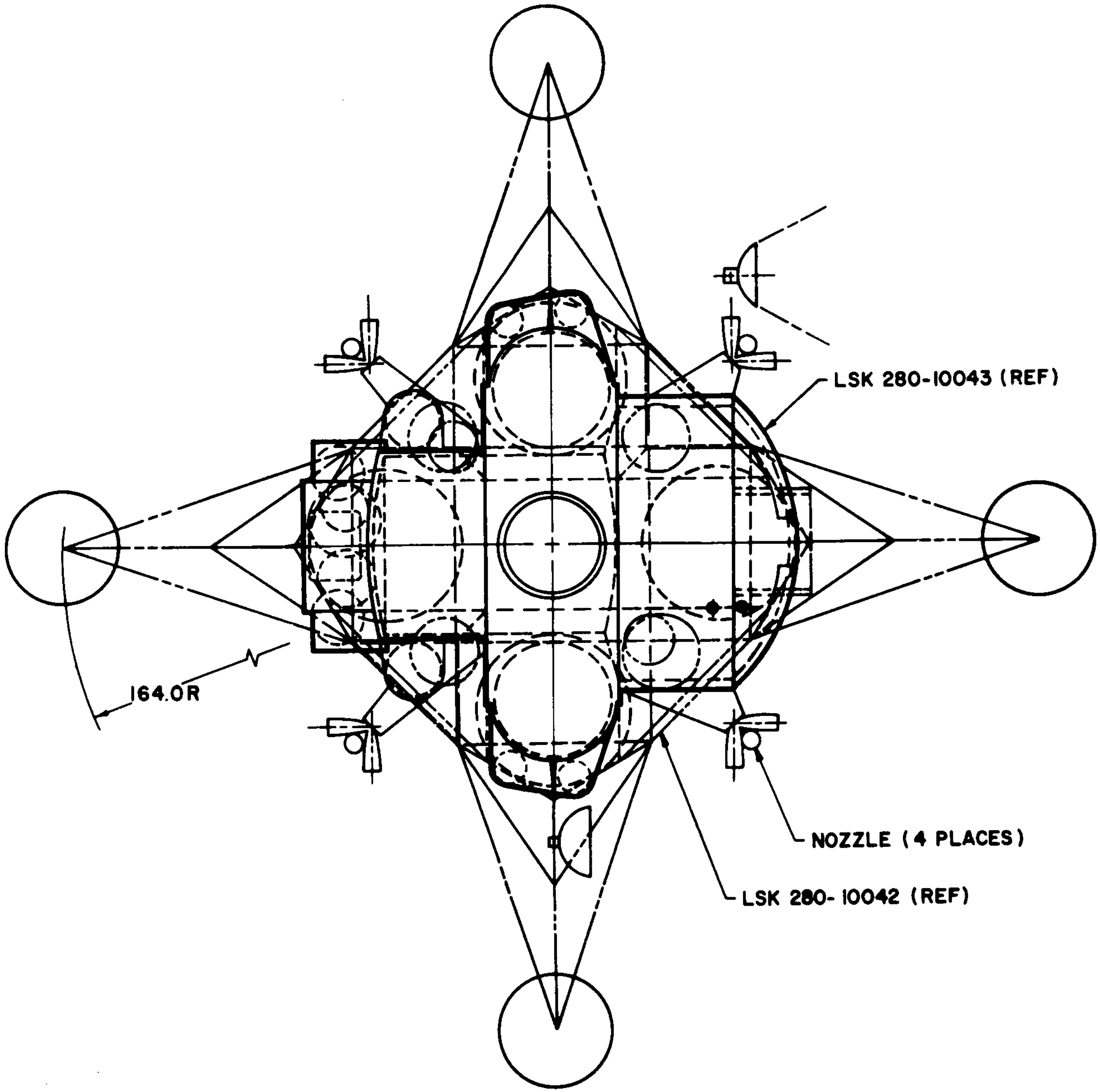

Figure 8.- Lunar Excursion Module Configuration

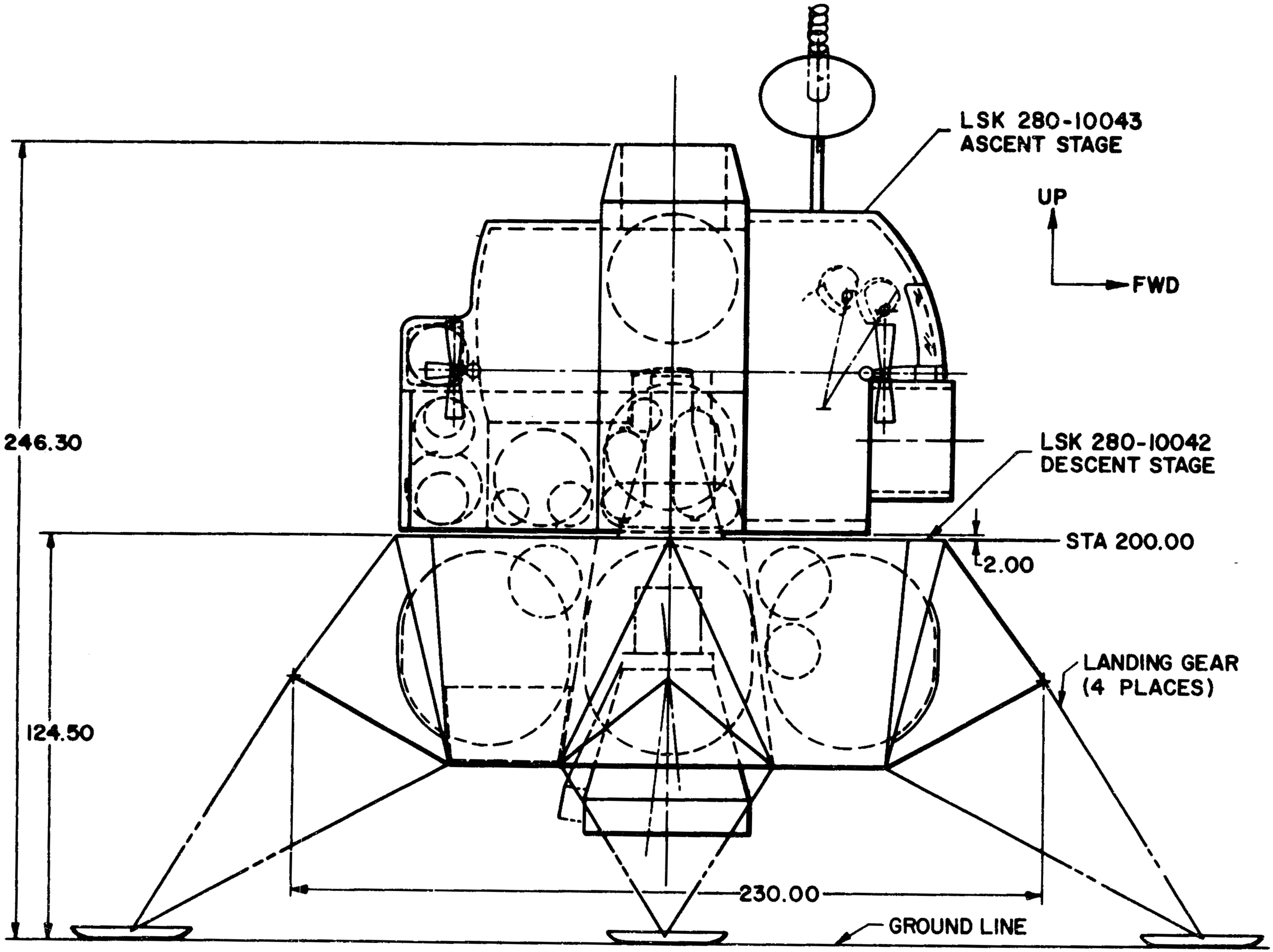

Figure 8.- Lunar Excursion Module Configuration (Concluded)

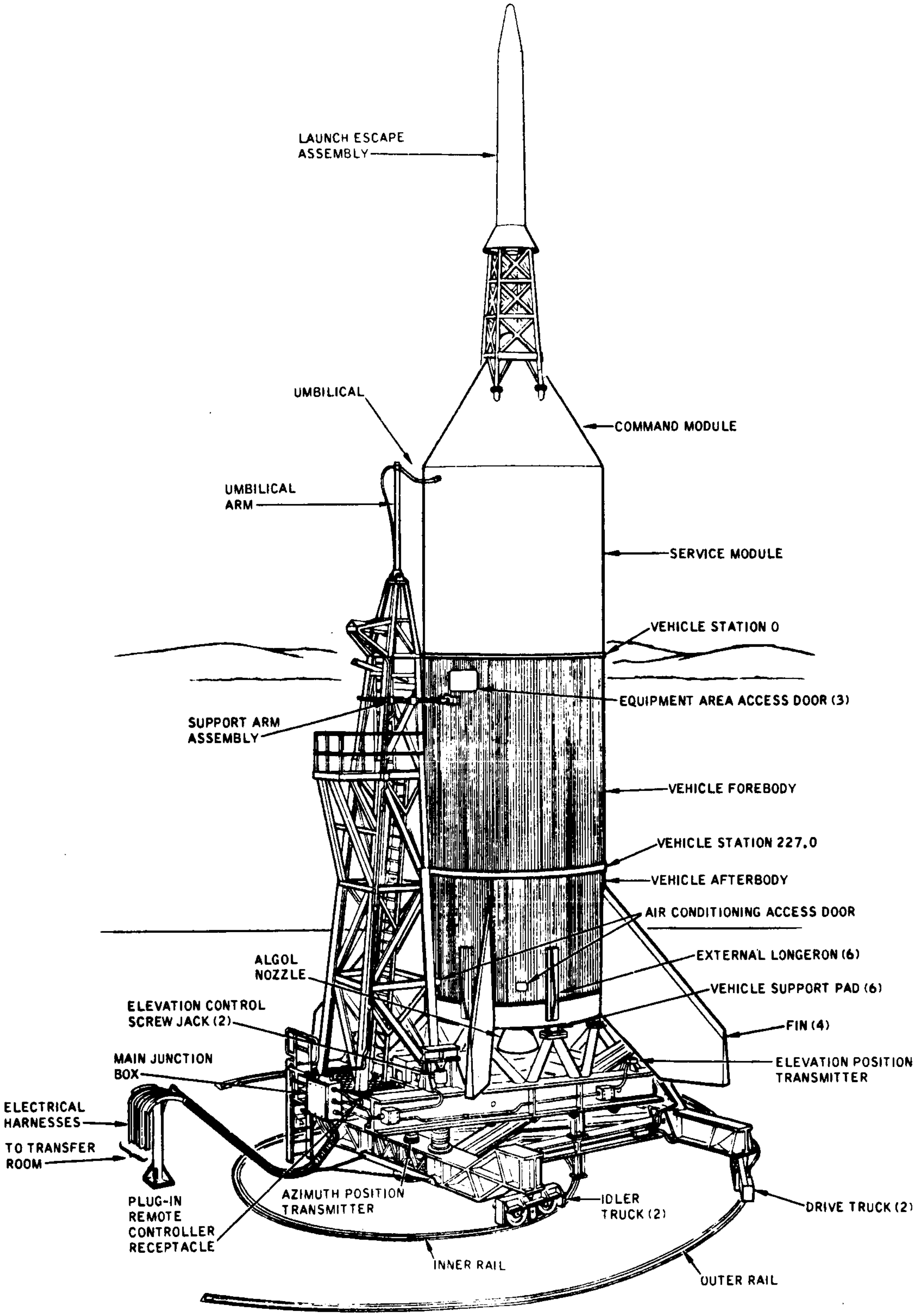

Figure 9.- Little Joe II Launch Vehicle and Launcher

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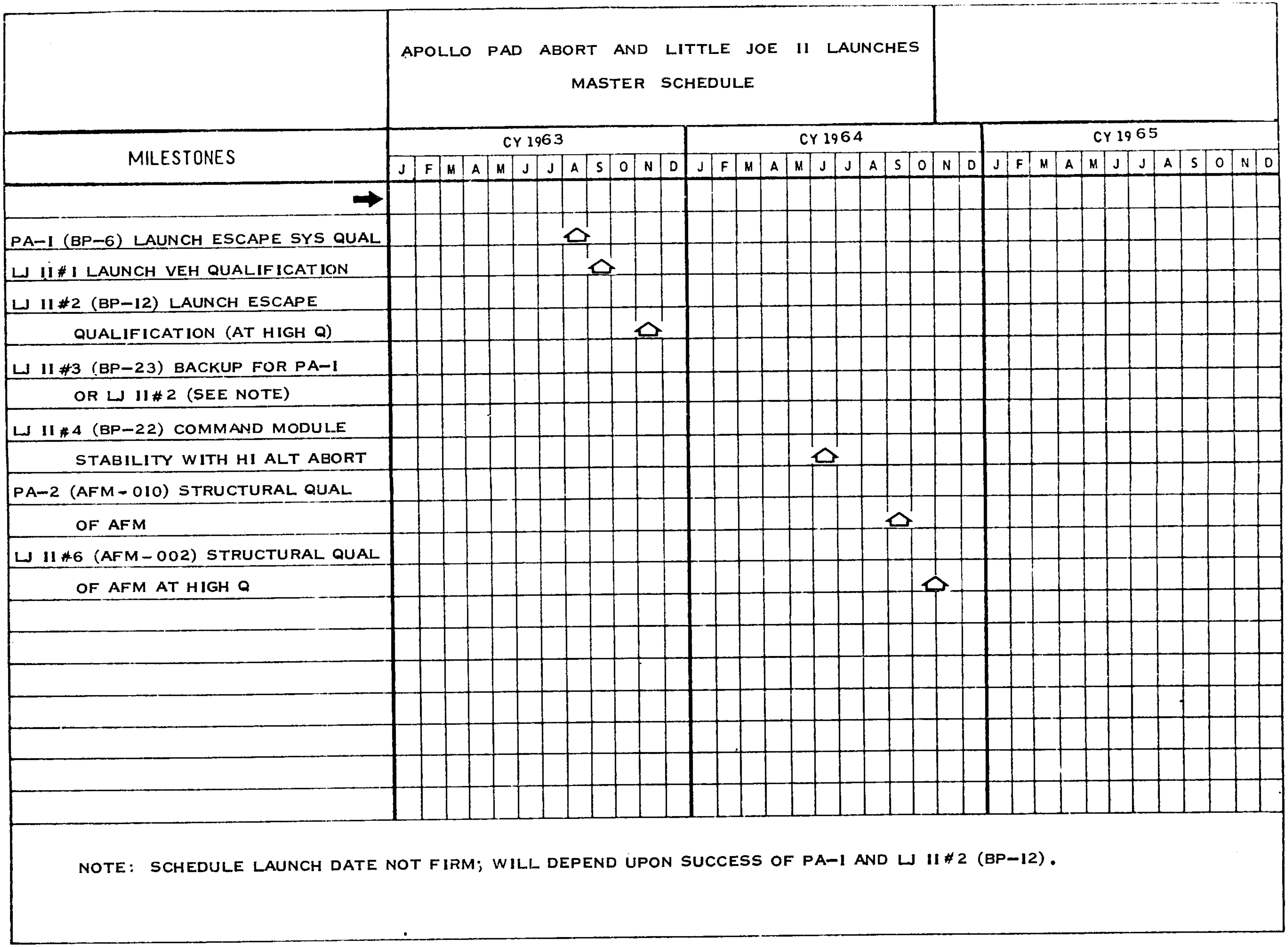

Figure 10.- Apollo Pad Abort and Little Joe II Launches (as of June 30, 1963)

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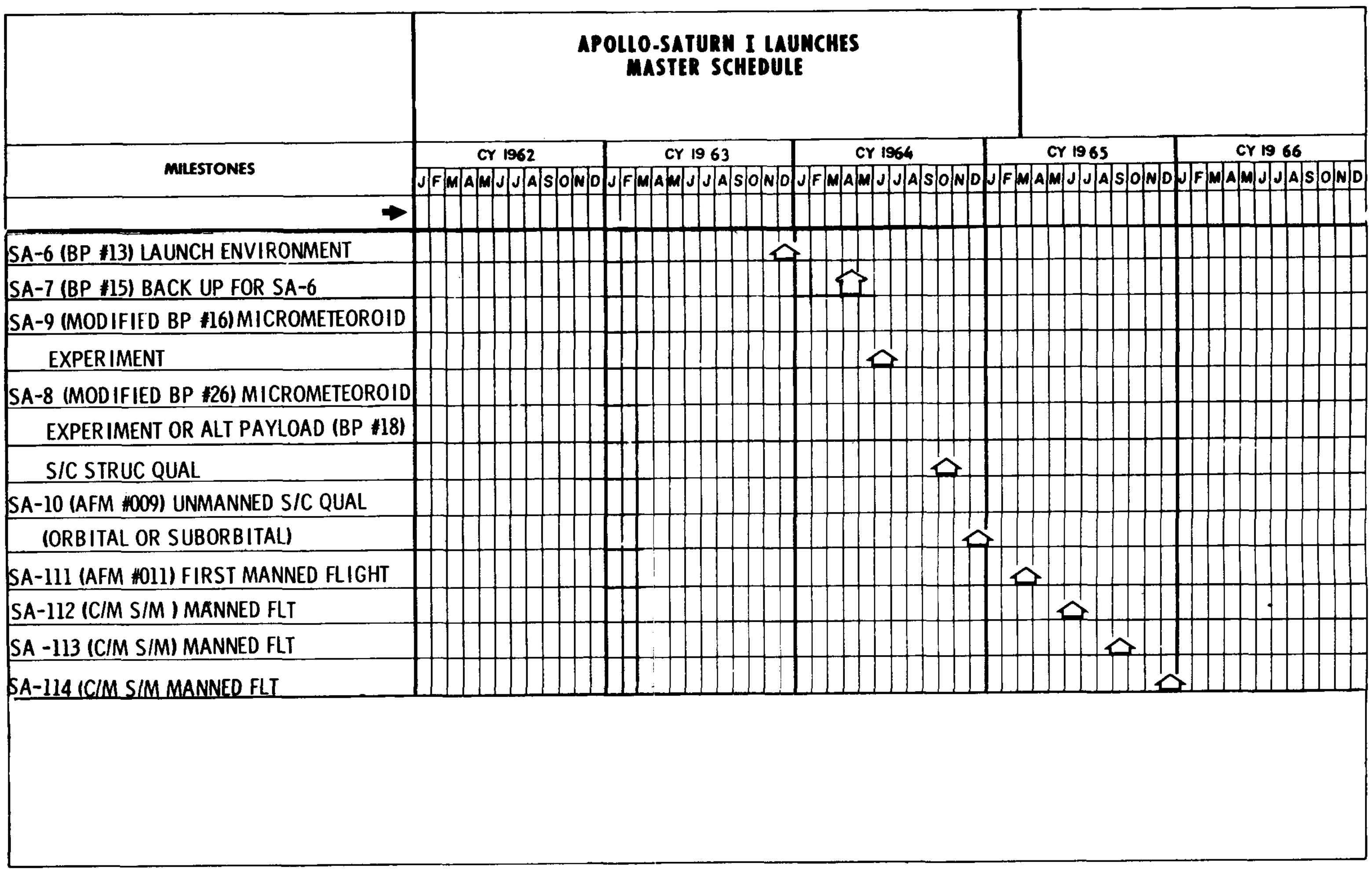

Figure 11.- Apollo Saturn I Launches (as of June 30, 1963)

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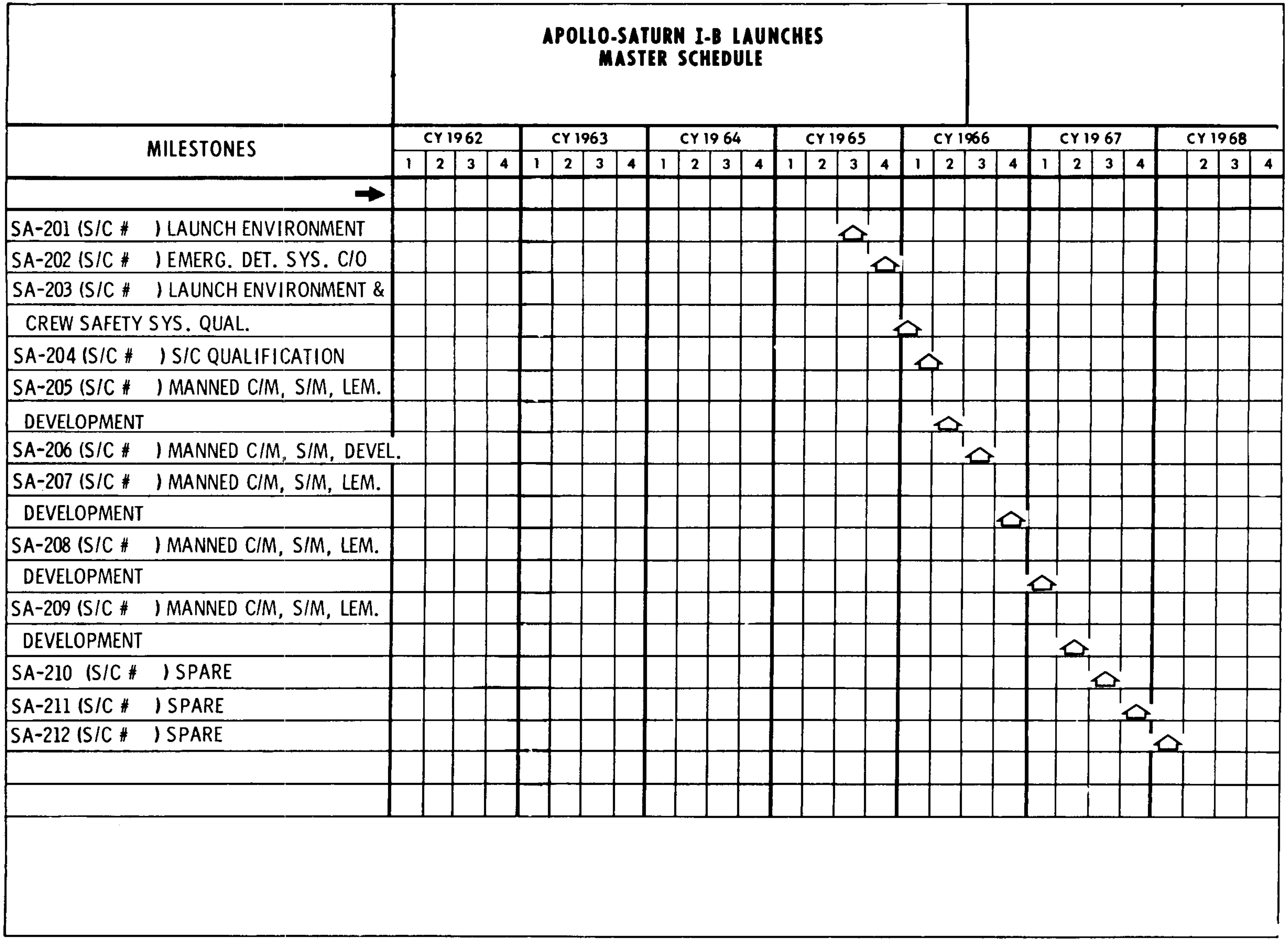

Figure 12.- Apollo Saturn I-B Launches (as of June 30, 1963)

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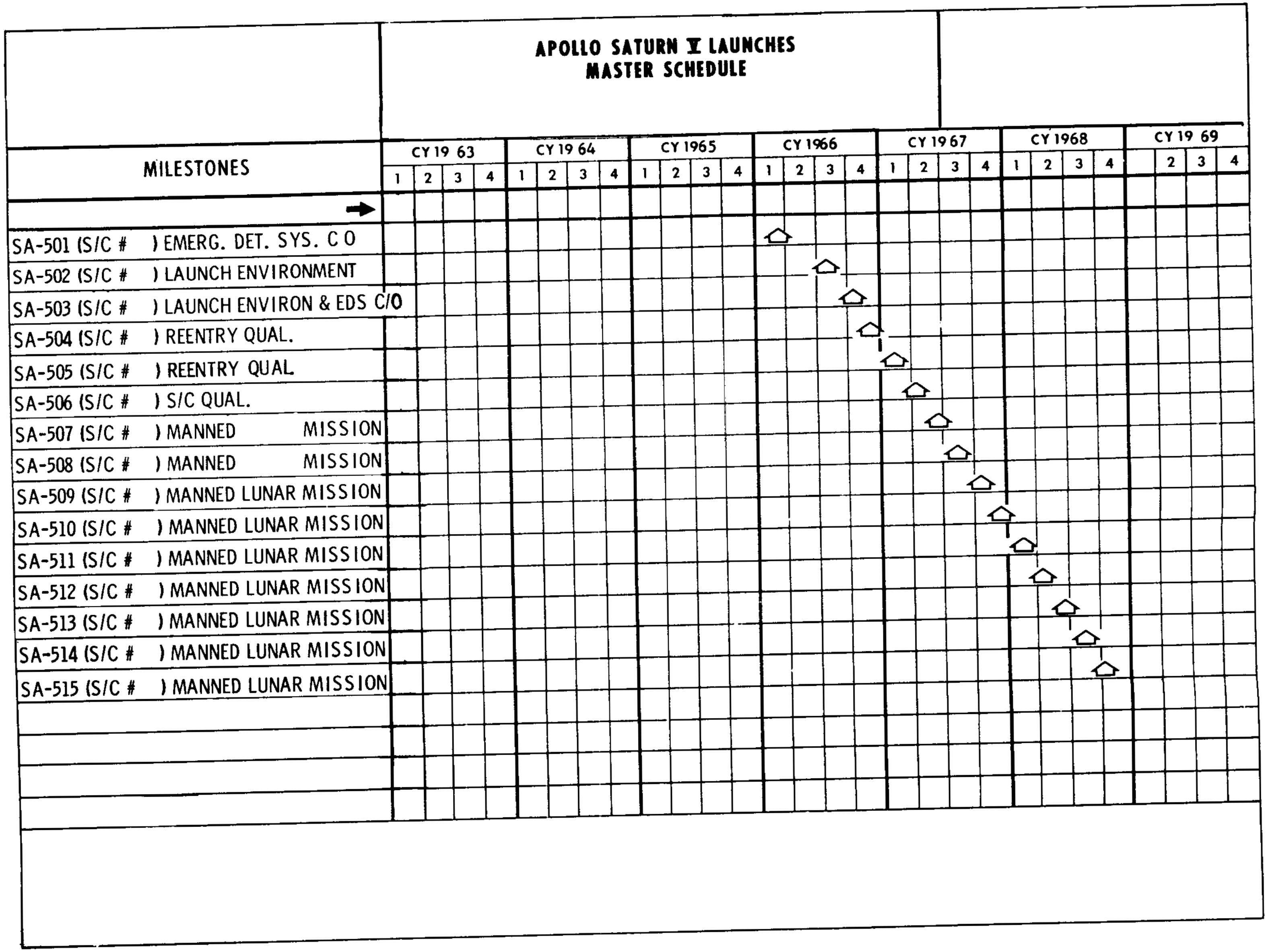

Figure 13.- Apollo Saturn V Launches (as of June 30, 1963)

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